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Final Report

to

Earth Sciences Division
Department of the Army
U.S. Army Natick Laboratories
Natick, Massachusetts 01760

Contract No. DA 19-129-AMC-684(N)

# INVESTIGATIONS OF MARINE PROCESSES AND COASTAL LANDFORMS NEAR CRESCENT CITY, CALIFORNIA

Volume I: Technical Discussion

15 July 1967



by

James A. Roberts
Donald M. Bleistein
with
Robert Dolan

Atmospheric Research Group
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ARG67 FR-616

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ABSTRACT

Volume I of this report presents the results of a study of the dynamics of South Beach located adjacent to Crescent City, California, conducted under Contract No. DA 19-129-AMC-684(N) between Atmospheric Research Group and the U. S. Army Natick Laboratories. The objectives of the work were twofold: (1) to relate the beach dynamics to the overall morphology of the Smith River Plain, the region in which the beach is situated, and (2) to develop techniques to accomplish the study. The Smith River Plain is a lowland segment of the Klamath Mountains Province. The structure of the Plain is controlled by diastrophism. The general configuration of the Plain is controlled by location, orientation, and exposure of bedrock. To conduct the study within the scope of the project necessitated the selection of several key sites and the utilization of specialized sampling techniques for seasonal profiling and for short, intensive study. South Beach is an arcuate beach, about four miles in length, composed principally of medium to fine grained sands. The beach reflects only minor seasonal or tidal variability, and its configuration is controlled by its exposure to wave forces by local geomorphology.

Volume II presents a tabulation of the statistics collected during the study. They include: (1) summary of wind speed and wind direction data from an automatic Mechanical Weather Station located on South Beach, (2) measurements of beach dynamics on South Beach, (3) analysis of mineralogy of beach sediments, (4) explanation of the problems experienced with the underwater experiment, and (5) data from the offshore experiment.

## FOREWORD

This study was performed under the auspices of the U. S. Army Natick Laboratories under Contract No. DA-19-129-AMC-684(N). The field study was conducted during an eighteen-month (18) period ending 23 December 1966. As proposed, a total of twelve (12) man-months of effort was expended on the study.

Particular acknowledgment should be made of the services provided by several people from the Crescent City area. They were: Cliff Lewis, Roy Magnusun, Jerry Needy, Jay Clark, and William Melnikoff, each of whom helped with the field studies. Thanks would be given, if possible, to each of the residents of Crescent City who in their passage onto and along the beaches did not disturb the sometimes nuisance paraphernalia of the experiments.

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## List of Figures

Maps in Packet:

## I. INTRODUCTION

### Objectives

This report presents the results of an investigation of the dynamics of South Beach located adjacent to Crescent City, California, and the relationship of that beach to the geomorphology of the Smith River Plain (Figs. 1, 2, and 3). Although the primary objective was to investigate the beach processes and their relationship to the overall region, a secondary, but significant, objective was to develop suitable techniques to accomplish that study. Therefore, the report presents a discussion of the geomorphology of the region and a description of its coastal zones, an explanation of the experiments done on the beach, and a summary of the relationships of the factors affecting the dynamics of South Beach.

### Location

The Smith River Plain is a rectangular coastal lowland of about 100 square miles located approximately 25 miles from the Oregon border in northwestern California. The area is about 280 miles north of San Francisco Bay and 275 miles southwest of Portland, Oregon. The approximate geographic center of the area is 41° 45' North latitude and 124° 13' West longitude. The general region of consideration extends from the mouth of the Smith River to the mouth of the Klamath River, a distance of 28 miles.

### Previous Investigations

Only a few previous geologic or geographic investigations have been made in the study region. Of these, the information of greatest value was found in an article by William Back entitled "The Geology and Ground Water Features of the Smith River Plain, Del Norte County, California." This report and the other previous works by Irwin (1960), Maxon (1933), and Taliaferro (1942) are referenced in the bibliography.

The Atmospheric Research Group's (ARG) initial investigation in Crescent City was started in April 1964.* That investigation was limited to two subjects: (1) studies of the subaerial effects of precipitation and wind on the backshore, and (2) studies of the effects of waves on the beaches. It had also been hoped to study the effects of the tsunami of March 1964 as a geomorphic agent in the shaping of the Crescent City Beach. However, despite the fact that the field work was initiated in early April 1964, the beach was substantially changed before field observation could be initiated. The U. S. Army Corps of Engineers, San Francisco District, had all debris removed from the beach after the tsunami. The removal was ordered by the Corps to prevent possibly

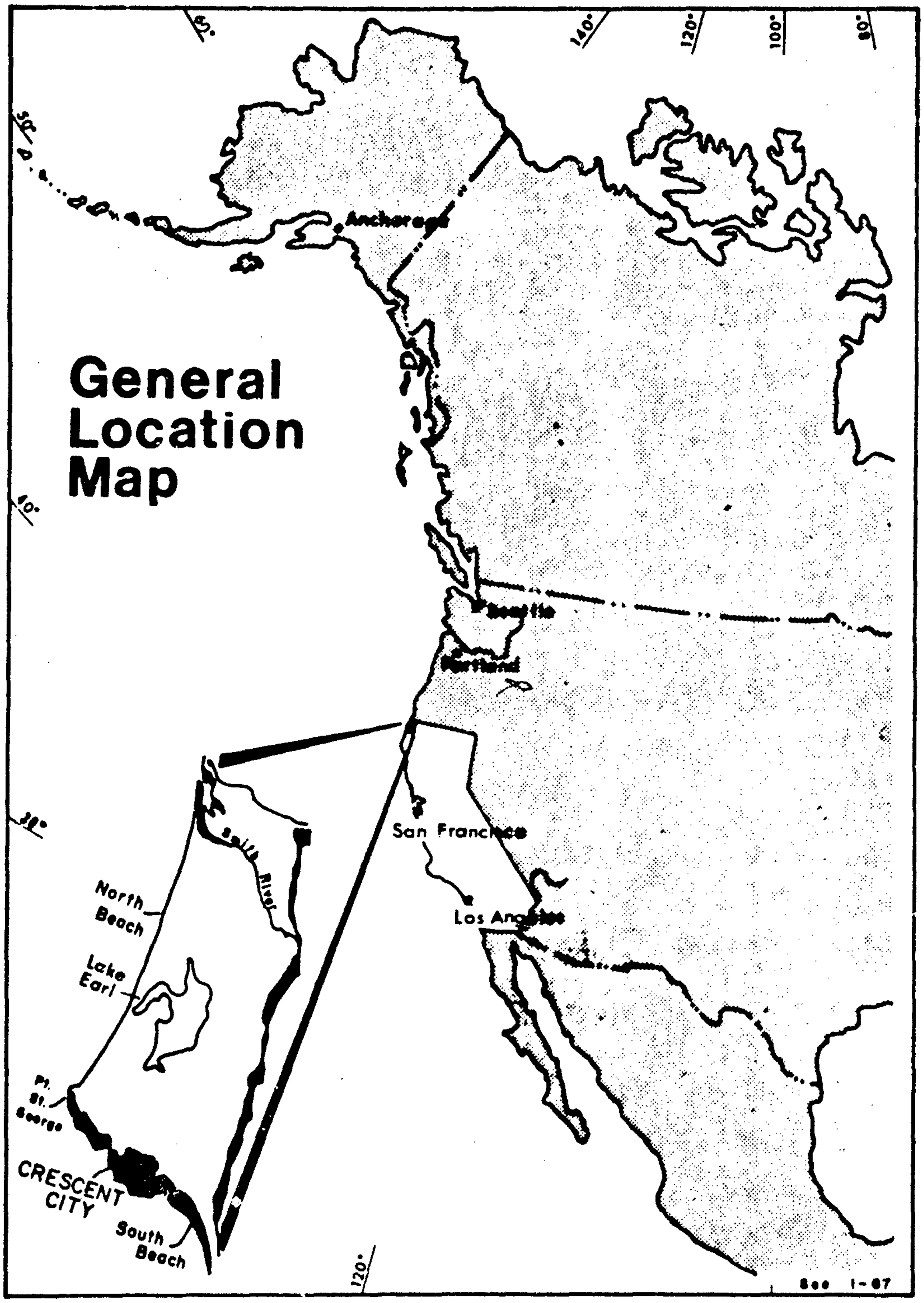
General Location Map
140°
120°
100°
80°
50°
40°
North Beach
Lake Earl
Smith River
CRESCENT CITY
South Beach
120°

Fig. 1

Fig. 2 Northern half of South Beach. View to northwest across the harbor at Crescent City, California, toward Point St. George (August 1965).

Fig. 3 Southern half of South Beach. View to southeast over area of intensive beach studies with the coast range in background (August 1965).

contaminated material from becoming a health hazard. Hence it was impossible to study the specific effects of the tsunami on the beach. During the study, however, it was observed that despite strong winter storms, South Beach showed very little variation. This observation was the primary stimulus for the present study.

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*ARG 64 FR-186, "The Effects of Wind and Precipitation on the Modification of South Beach, Crescent City, California," 14 October 1964, under Contract No. DA-49-092-ARO-38.

## II. GEOMORPHOLOGY OF THE SMITH RIVER PLAIN

### Evolution of the Landscape

The Smith River Plain is a lowland segment of the Klamath Mountains Province of northern California (Maps 1 and 2).* The evolution of the Plain and surrounding highlands has been dominated by diastrophism. The eastern boundary of the Plain was formed by the Del Norte fault (Structural Trend I), the northern boundary by transverse movement (Structural Trend II), and the southern boundary by the uplift and tilting of a bedrock platform (Structural Trend III).

Prior to the Pleistocene, normal faulting along Structural Trend I (Fig. 4) resulted in the lowering of the Jurassic bedrock platform of the Plain below the general level of the adjacent Klamath Mountains. During the same period, Structural Trend II resulted from both normal and strike-slip displacement and let to the indentation of the northern segment of the Plain. Tilting and uplift along Trend III during the Pleistocene and again post-Pleistocene, elevated the area of Point St. George slightly higher than the remainder of the Plain. Hence the relative deformation at Point St. George appears to have been the pivotal point around which the basic morphologic differences of the Plain have been derived.

An article by Wilson (1964) refers to a series of anomalous conditions associated with the north end of the San Andreas Fault system. Although the article does not relate these anomalies specifically to the Smith River Plain, it is of interest to compare his findings with this analysis of the Plain. As illustrated in Fig. 5 which is patterned after one of the figures in Wilson's article, it appears that an irregularity similar to those shown by Wilson in the offshore zone may be related to the conditions which formed the basic structure of the Plain.

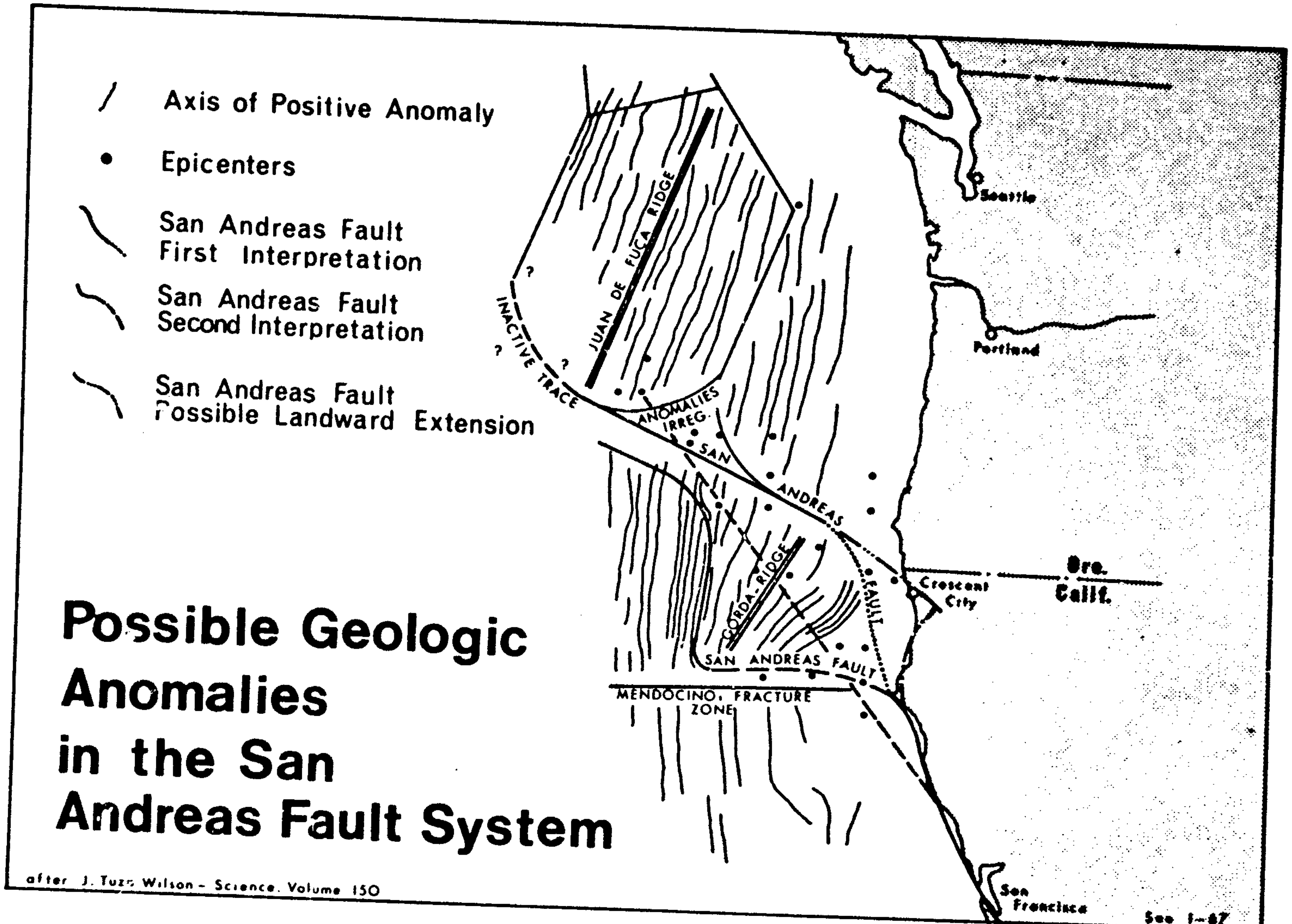
### The Present Landscape

Map 2 illustrates the present geomorphology of the Smith River Plain. The following discussion relates to the profiles indicated and illustrated on Map 2.

Profile A-A' extends from Round Rock in the offshore zone to the confluence of the Klamath Mountains and the Smith River Plain. The extreme western margin of this profile consists of materials from the northern coastal range Jurassic primary materials. The middle area of the profile, approximately from a line of a fault which appears to extend

*The reader should refer to Maps 1, 2, and 3 enclosed in the packet bound at the end of this volume.

Fig. 4 Structural Trend I looking from north to south along U.S. Highway 101 (August 1965).



Axis of Positive Anomaly
Epicenters
San Andreas Fault
First Interpretation
San Andreas Fault
Second Interpretation
San Andreas Fault
Possible Landward Extension
Possible Geologic Anomalies in the San Andreas Fault System
JUAN DE FUCA RIDGE
INACTIVE TRACE
IRREG. ANOMALIES
SAN ANDREAS
FAULT
GORDA RIDGE
SAN ANDREAS FAULT
MENDOCINO FRACTURE ZONE
Seattle
Portland
Crescent City
Ore.
Calif.
San Francisco
after J. Tuzo Wilson - Science. Volume 150


Figure 5

from Whaler Island toward Sister Rocks, is an area of recent littoral materials. The eastern margin consists primarily of the Pleistocene Battery Formation of fluvial materials.

Profile B-B' extends from Point St. George to the Klamath Mountains and consists of a very narrow zine of Jurassic material at Point St. George inland to the marine terrace, the Pleistocene Battery Formation (fluvial). A zone of inactive dunes is shown on the western one-quarter of the profile. The eastern half of the profile reflects the dissection of Elk and Jordan Creeks. This material consists primarily of the fluvial Battery Formation with small areas of recent fluvial deposits along the stream courses. The eastern end of the profile again reflects the Jurassic material of the northern coastal range.

Profile C-C' extends from the present littoral zone into the Jurassic mountain mass. The extreme western margin of the profile is a zone of active sand movement and dune formation. A major dune field extends inland to the Lake Earl area, about one-third of the profile. The inland margin of Lake Earl is a recent reworking of the Pleistocene Battery Formation. The eastern one-half of the profile is dominated by the Fort Dick terrace (after Back) and a second terrace, shown here as the King Valley High.

Profile D-D' extends from near the present mouth of the Smith River through the active zone of deposition of the Smith River Plain to the Klamath Mountains. The profile consists of an area of recent oceanic deposition, recent fluvial plain from the active Smith River, an older Pleistocene flood plain associated with earlier outwash of the Smith, a narrow fluvial terrace from the Pleistocene period, and a fan area which is also believed to be of Pleistocene age. The Jurassic material again forms the eastern boundary of this profile.

Profile E-E' extends from Castle Rock (Fig. 6) to the present mouth of Rowdy Creek. The southwestern end of this profile is Jurassic material. Onshore, the profile starts in bedded Pliocene marine sands and shales (Fig. 7) and extends through active dune sands, relic dune sands, areas of recent deposition near Lake Earl, and through a Pleistocene swell which reflects several outcrops of Jurassic materials. The profile crosses the present bed of the Smith River and a fan resulting from outwash from Rowdy Creek ends in the Jurassic mountain area. This profile illustrates the general tilting of the Smith River Plain from the south to north which resulted in the migration of the mouth of the Smith River toward the north end of the Plain.

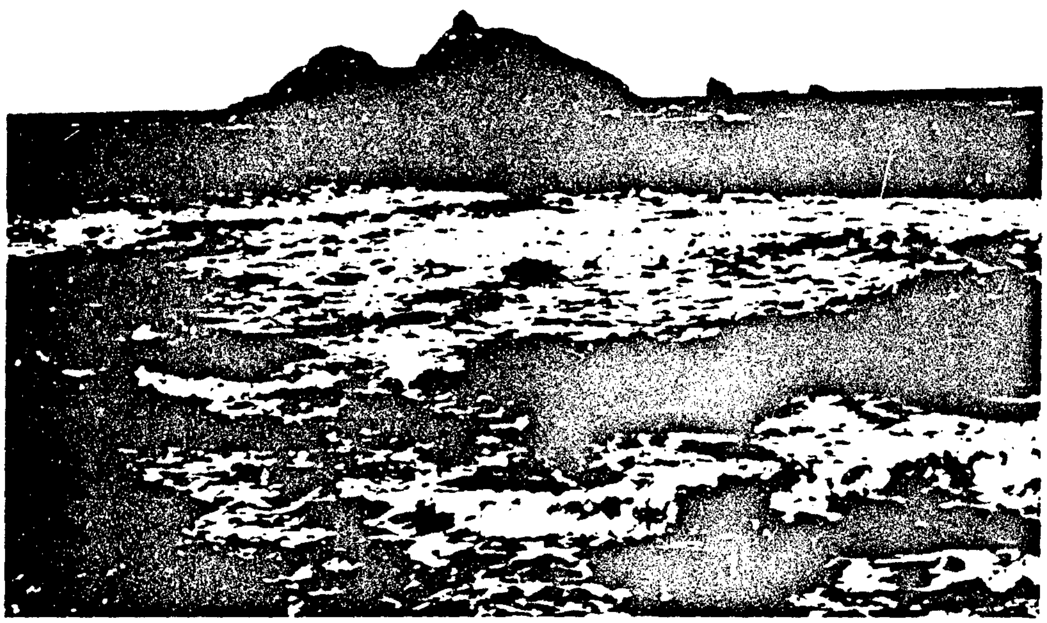


Fig. 6 Castle Rock. Jurassic outcrops at Point St. George; note possible continuation of Pliocene terrace (December 1965).

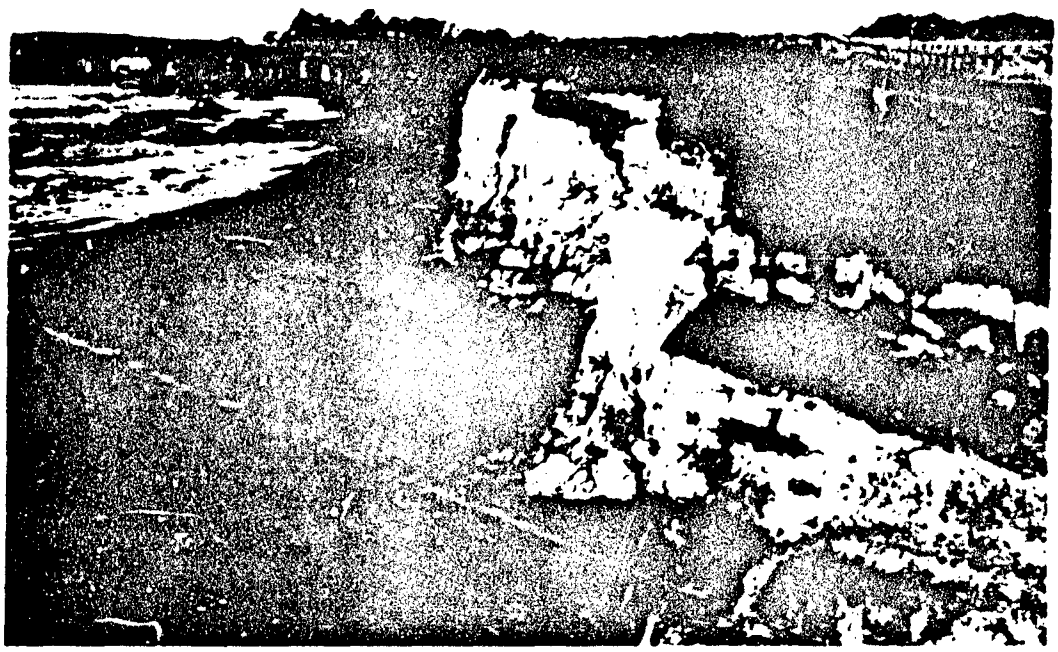


Fig. 7 "St. George Formation", bedded Pliocene marine sands and shales exposed at Point St. George behind "Pebble Beach" (December 1965).

## III. THE COASTAL ZONE

The general configuration of the coast of the Smith River Plain is controlled by the location, orientation, and exposure of bedrock. The position and alignment of each beach reflects close correlation between availability of sediment and exposure to the forces of breaking waves. The configuration of any specific beach is determined by its location in relation to energy dissipation across the bedrock sea floor and against the terrace or back-beach margins. Where energy is dissipated against headlands, such as those north of the mouth of the Smith River, along the southwestern facing reaches of Point St. George, and at the extreme south end of South Beach, the major morphologic activity is erosion. Where an excess of fluvial materials is available and where wave energy is slight, deposition occurs.

The beach north of Point St. George is stable. This is apparently a result of the balance between the effects of wave action and the supply of sediment from the Smith River. South Beach is stable because of the apparent entrapment of materials within the beach area. The latter beach will be discussed in detail in Section V.

### Processes Affecting Coastal Features

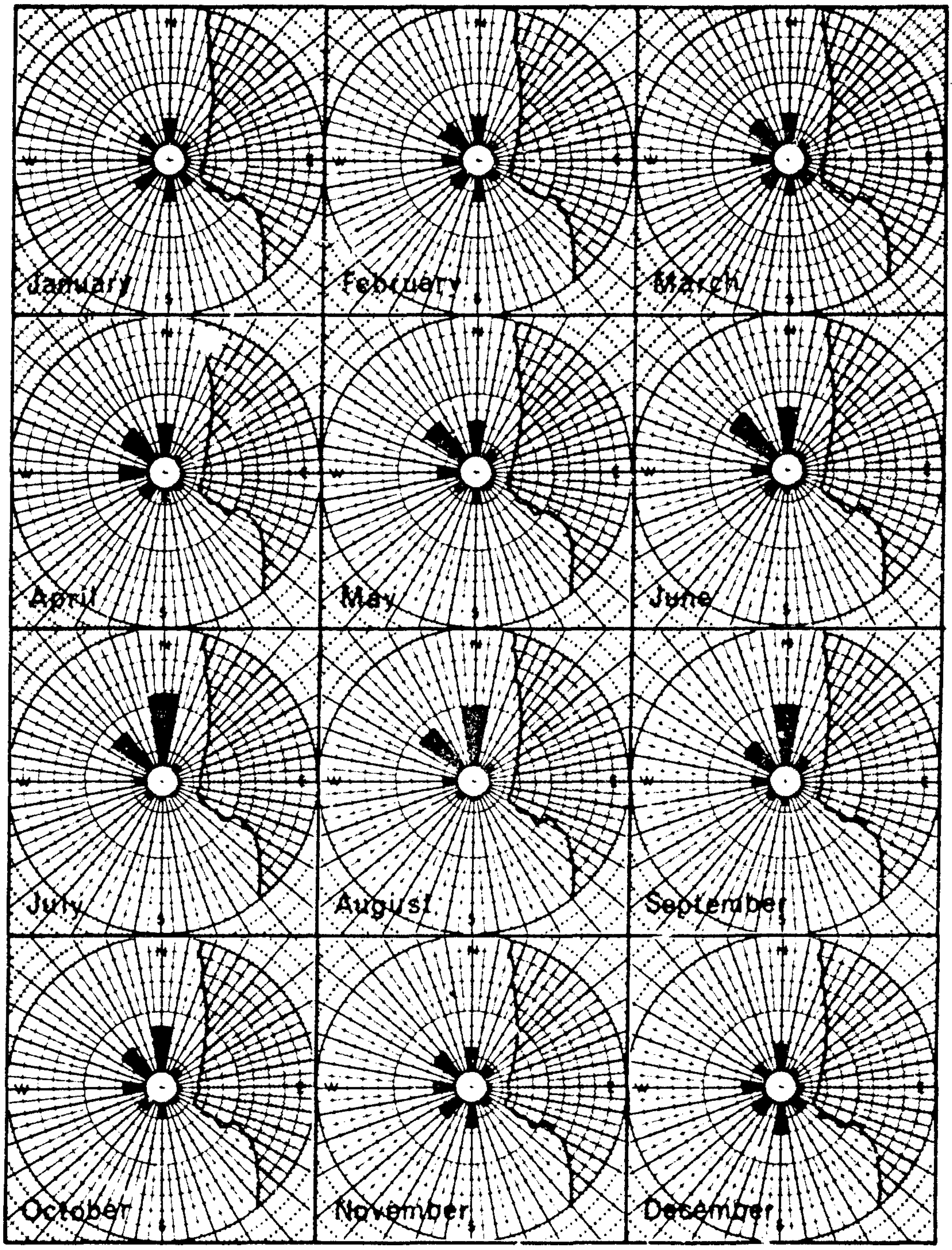
The principal processes which control the formation of the coastal features in the Crescent City area are wind, waves, littoral currents, and tides. The salient characteristics of each of these processes is described in this section.

#### Wind

The prevailing winds affecting the Smith River Plain are from the northwest (Fig. 8). Winds recorded during the study are summarized in Volume II.

It should be noted that the topographic features of Point St. George modify the prevailing wind flow. From the data collected during the study, it appears that there is a major counter-clockwise eddy set up by Point St. George and that there is subsidence of the air flowing over the rise of the Smith River Plain. As a result, the winds at South Beach are often onshore or exhibit a modest onshore component even during periods of rather strong northwesterly flow over the northwesterly-exposed portions of the Plain.

The effects of these prevailing northwest winds are indicated by the extensive dune field north of Point St. George. The dunes result from high wind energy coupled with a surplus of sediment from the Smith River.




**Prevailing Wind at Smith River Plain**

Direction
Frequency

3 %
10%
20%
40%

See 1-67 – after Climatological & Oceanographic Atlas for Mariners – Volume II – N. Pacific O.

Fig. 8

About 75 per cent of the storms affecting Crescent City approach the area along storm tracks from the northwest while only about 25 per cent of the storms affecting the area follow tracks from the southwest (Fig. 9). These latter storms are significant because they usually cause heavy precipitation and have strong wind fields. The most frequent storms which affected the study area during the period 1964-1966 followed northwesterly storm tracks, occurred in December 1964 and in December 1965. In December 1964, the area inland from Crescent City was subjected to seven days of extremely heavy rain. This rain, coupled with the water from the melting of a heavy snowpack which had previously fallen in the same area, caused the Smith River, the Klamath River, and adjacent rivers to exceed their normal winter flow. The debris and silt from both river systems were transported into the study region by these rivers during the storm period. This conclusion was based on airborne observations and identification of ownership tags on logs found on South Beach.

After the storms of December 1964, it was hypothesized that much of the debris and sediment transported into the Crescent City area was delivered as a result of such catastrophic storms following the southerly track. It was anticipated that if the same conditions were to occur in the following winter it would be possible to document this hypothesis.

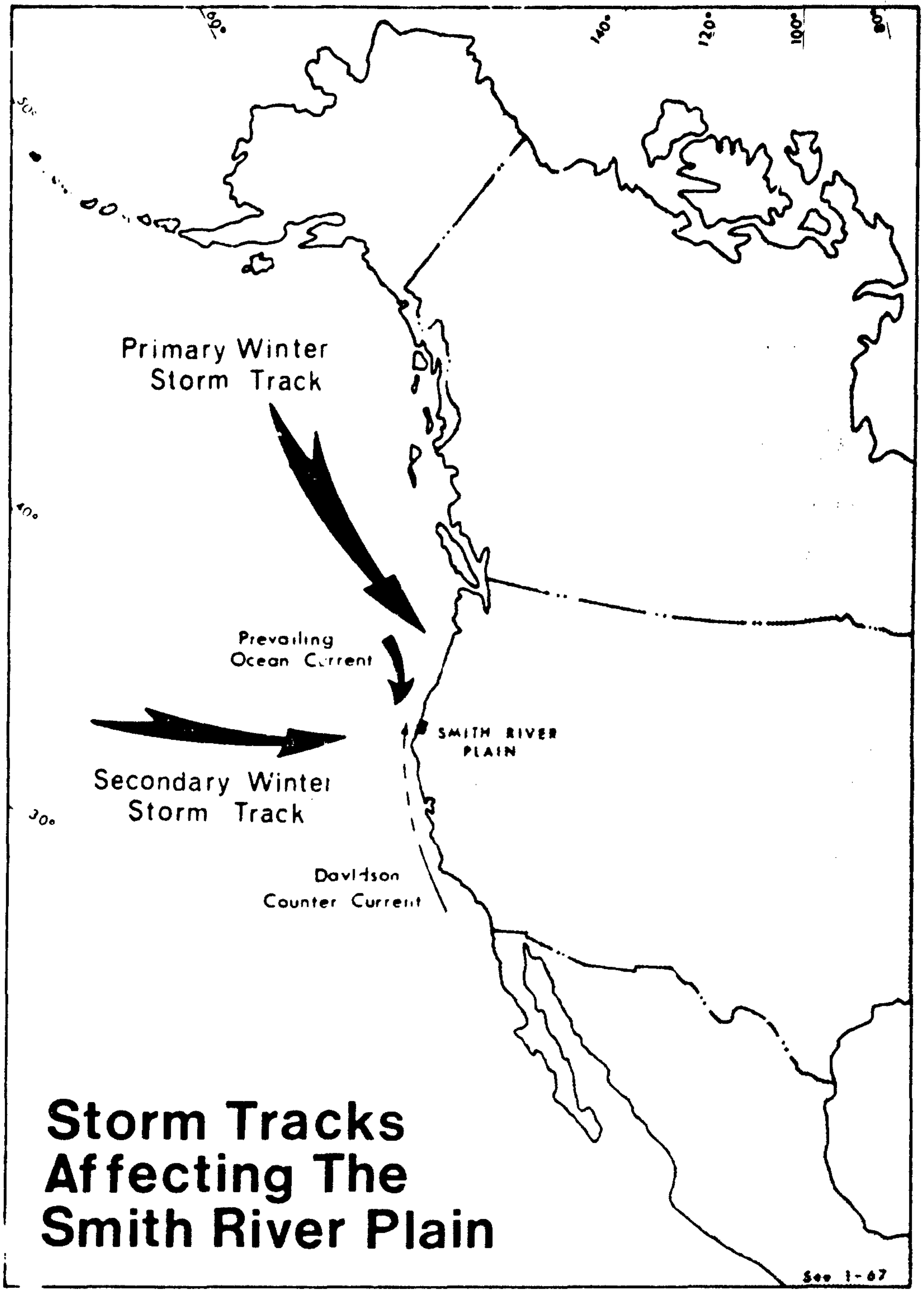
In winter 1965, again during late November and early December, the area was subjected to heavy rains in the inland region from a series of storms following the southerly track. However, unlike the previous year, excessive flooding did not occur.

## Waves

The energy produced by wind-generated waves* is frequently the most important factor in shaping beaches. The amount of wave energy that actually contributes to the dynamics of a beach is a function of how much wave energy is available in deep water, less that amount dissipated, principally through refraction, bottom friction, breaking, and internal friction.

Inspection of U. S. Weather Bureau synoptic charts reveals several interesting facts about waves approaching Crescent City. The greatest amount of "swell" energy is generated in winter by the winds in storms

*Wind waves are classified by whether or not active wave generation includes the point where observations are being made. If a wind is generating waves locally, these waves constitute a "sea." Waves which have propagated longer distances beyond the region of their active generation are manifest as ocean "swell." In contrast to sea, swell can be present at a location where there is no local wind.



160°
140°
120°
100°
80°
50°
40°
30°
Primary Winter
Storm Track
Prevailing
Ocean Current
SMITH RIVER
PLAIN
Secondary Winter
Storm Track
Davidson
Counter Current
Storm Tracks
Affecting The
Smith River Plain


Fig. 9.

associated with intense low pressure systems which travel from west to east. These winter storms may occur one after another as often as every three or four days; there may, however, be calm periods for as much as two weeks. Regardless of their frequency, the synoptic charts indicate, as stated previously, that about 75 per cent of these storms follow tracks from the northwest while the remaining 25 per cent follow tracks from the southwest. It is this latter group that provides the most potential swell energy for beach shaping.

The most frequent occurrence of "sea" is also in winter and is generated by wind associated with the aforementioned low pressure systems. The prevailing direction of winter sea in the study area is from south to southwest.

Figures 10 and 11 show coefficients of the height modification and the change in direction of waves as they pass from deep water (greater than 600 feet depth) to Crescent City harbor.* Refraction for South Beach and the harbor is similar since at both locations exposure to waves and offshore topography are essentially the same.

Figure 10 shows the large change in direction as waves pass from deep to shallow water for waves approaching Crescent City from the northwest quadrant. The reduction in wave height for waves approaching in this quadrant is given in Fig. 11. The bottom topography of St. George Reef is so complex that it is extremely difficult to determine just how waves are refracted in this region. Therefore, the refraction information for the northwest quadrant presented in the figures should be considered valid in only the most general sense.

Refraction of waves from the southwest quadrant is much less intense than for waves from the northwest quadrant because the bottom topography is much more regular and the direction of wave approach is more direct. In fact, there is a tendency for waves from the southwest to converge which causes a slight increase in wave height in passing from deep to shallow water. Hence the greatest potential wave energy directed toward South Beach is from waves with deep water directions from the southwest quadrant.

In spite of the rather large amount of wave energy occurring in the area in winter, observations made during the study and interviews with long-time residents indicate that South Beach is quite stable over the years.

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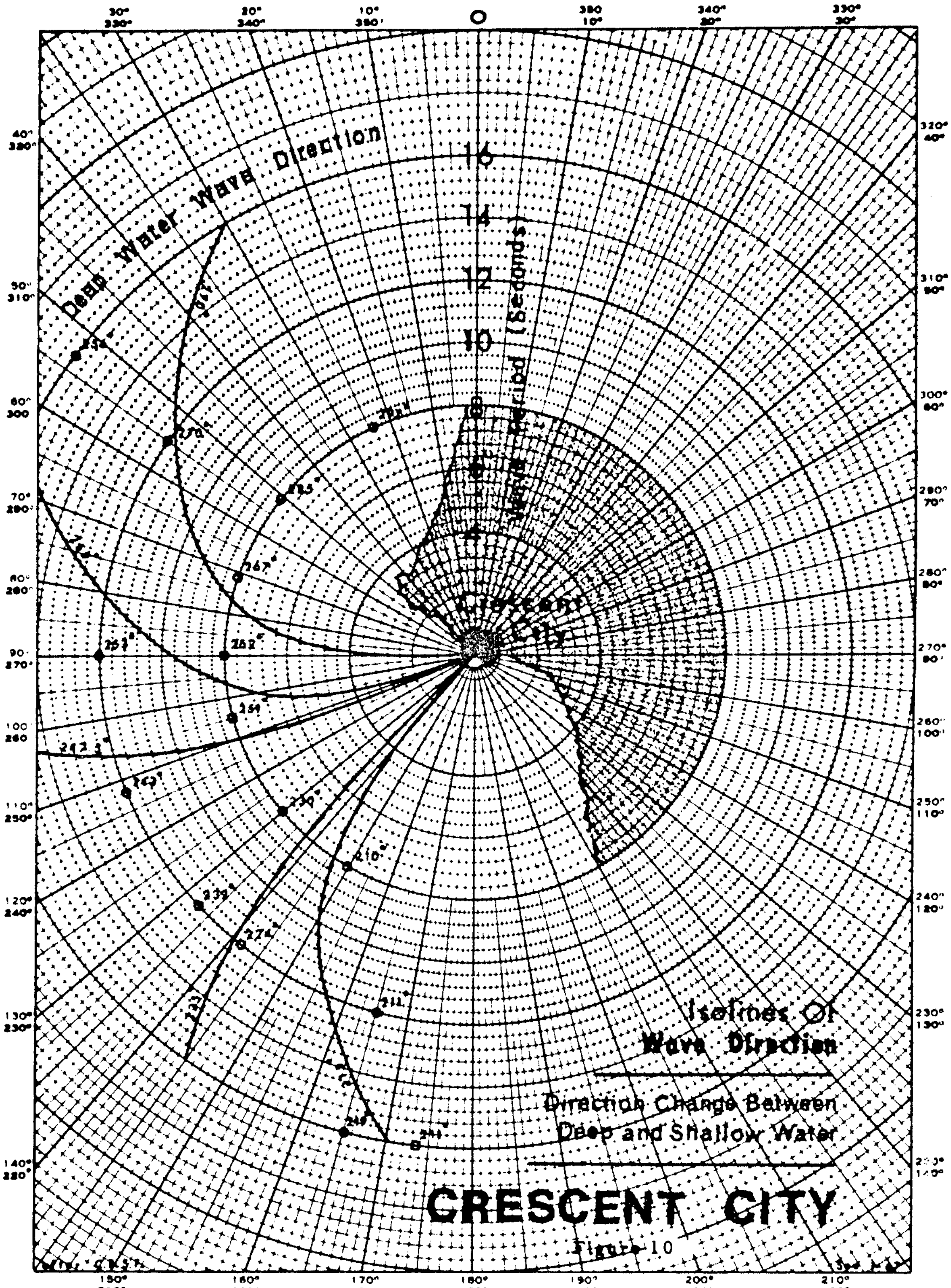
*Figures 10 and 11 were provided by the U. S. Army Corps of Engineers, San Francisco District, which has been collecting data on the Crescent City area for a hydraulic model study of the harbor. That study is being conducted under the direction of the U. S. A. C. E. Waterways Experiment Station, Vicksburg, Mississippi.


Deep Water Wave Direction
Wave Period (Seconds)
Crescent City
Isolines Of
Wave Direction
Direction Change Between
Deep and Shallow Water
CRESCENT CITY
Figure 10

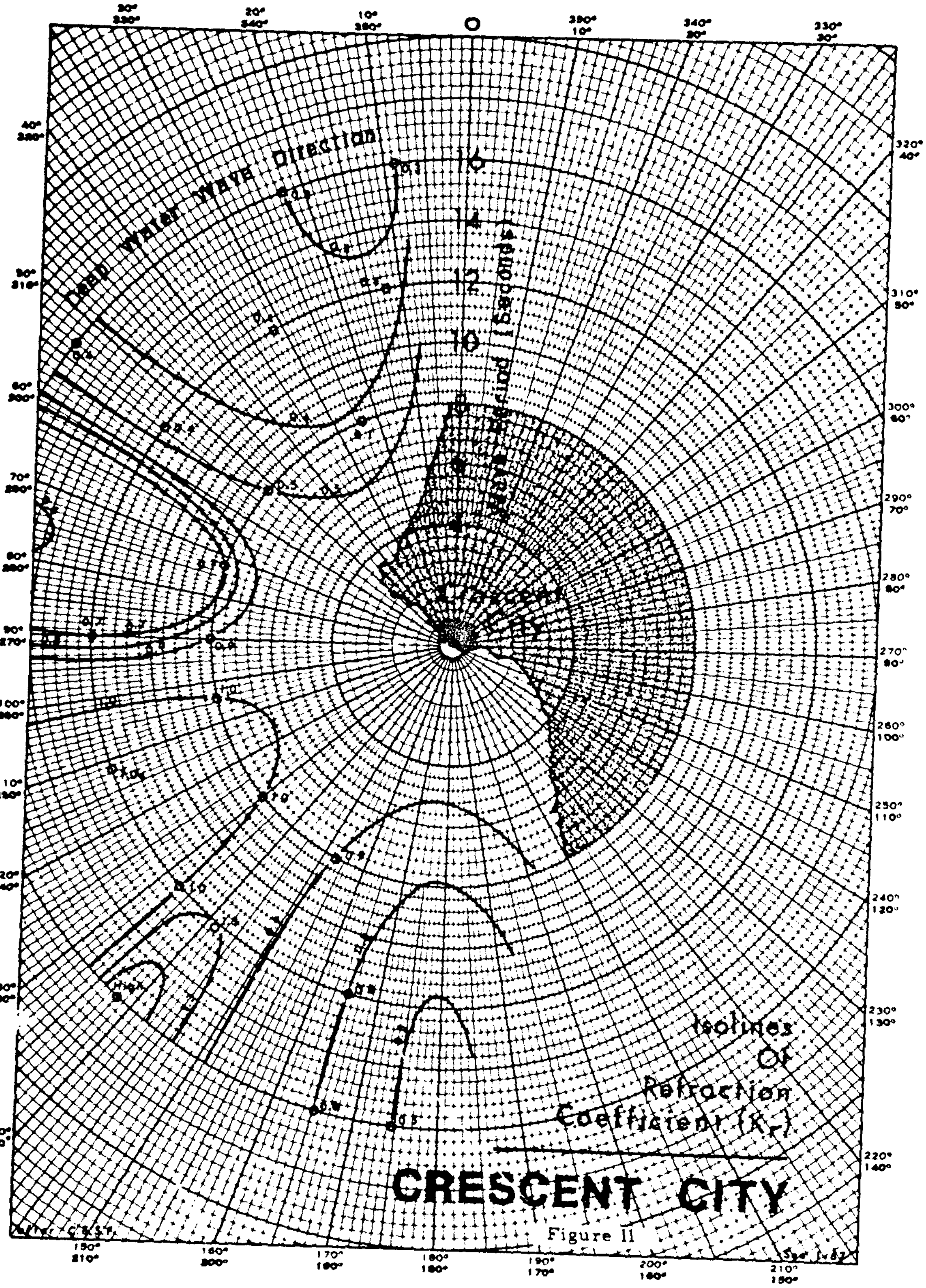

Deep Water Wave Direction
Wave Period (Seconds)
Isolines Of Refraction Coefficient ($K_r$)
CRESCENT CITY

Figure 11

During the winter it was also noted that the larger waves usually break at a considerable distance from shore, sometimes reforming and breaking again, and occasionally repeating the procedure a third time. Such a breaking wave pattern is due to the very gently sloping bottom which extends several hundred feet offshore from South Beach. The dissipation of wave energy by such a process is probably largely responsible for the apparent stability of the beach.

### Littoral Currents

The regional effect of littoral currents is to transport materials from north to south from the mouth of the Smith toward Point St. George. The regional pattern is disrupted near Point St. George where bedrock dominates the coastal landforms. As a result of the seaward projecting bedrock coupled with a focusing of wave energy, only small, coarse grained sand, pocket beaches are found in the area from Point St. George to Battery Point. Field observations during the course of this study suggest that only small quantities of sand move southward around Point St. George.

Along South Beach the littoral current pattern is controlled principally by angle of wave incidence at the beach. Current observations by a Corps of Engineers field crew and by the ARG field party, in summer 1965, suggest an eddy pattern in the region during the summer which may cause sediment to be transported northwestward toward Crescent City. The prevailing coastal current during the summer has a southerly set. Winter current patterns are similar except when related to the refraction of sea and swell from the southwest at which time the littoral current may be more closely related to local winds than to wave refraction.

The sediment characteristics of the coastal zone can be related to the pattern of littoral drift. North of Point St. George sediment sizes indicate a general direction of the littoral transport to the south. Mineral analysis reveals a concentration of more stable materials with greater distance from the sediment source - the Smith River. In addition, dune sands are finer near Point St. George than they are near the mouth of the Smith River. The fluvial marine terrace materials near the mouth of Jordan Creek are generally coarser and disrupt this overall trend along North Beach.

### Tides

Tidal curves for northern California are characterized by asymmetry. Near Crescent City the mean range is four feet, but extremes of nine and one-half feet occur during both June and December.

## Coastal Features and Regional Geomorphology

The coastal region from the Smith River to the Klamath River has been divided into ten zones (Map 2). The significant features of each of these zones are described in the following paragraphs.

### Zone I

Relatively narrow, steep, coarse-grained beaches reflecting exposure to high wave energy. Sediments are both fluvial and marine. Jurassic outcrops are common.

### Zone II

Near the mouth of the Smith River (Figs. 12 and 13) beaches are steep, coarse-grained, and narrow. The percentage of quartz is significantly higher than in Zone I. The large sand spit indicates drift from north and also illustrates the complex relationship between the bedrock channel of the Smith River and littoral drift.

### Zone III

Fluvial materials reqorked from ancestral Smith terrace (Jordan Creek) are reflected in beach characteristics. Beaches are steep, coarse, and relatively narrow. Fluvial gravels and cobbles are frequently arranged in cuspate form.

### Zone IV

Beach characteristics are similar to Zone II (Fig. 14). However, sediment is noticeably finer and slopes are flatter - probably reflecting increased exposure to northwest winds and distance from sediment source. A wide area of active dunes indicates the same general relationship.

### Zone V

Characteristics of beaches near Point St. George are determined by highly resistant Jurassic headlands (Fig. 15). Sea stacks and outliers are numerous. Sands are fine, with slopes varying according to exposure.

### Zone VI

Pebble Beach is a relatively narrow, flat, fine grained beach anchored between bedrock headlands. Although "pebbles" are

Fig. 12 Mouth of the Smith River and Structural Trend II. View to the east (August 1965).

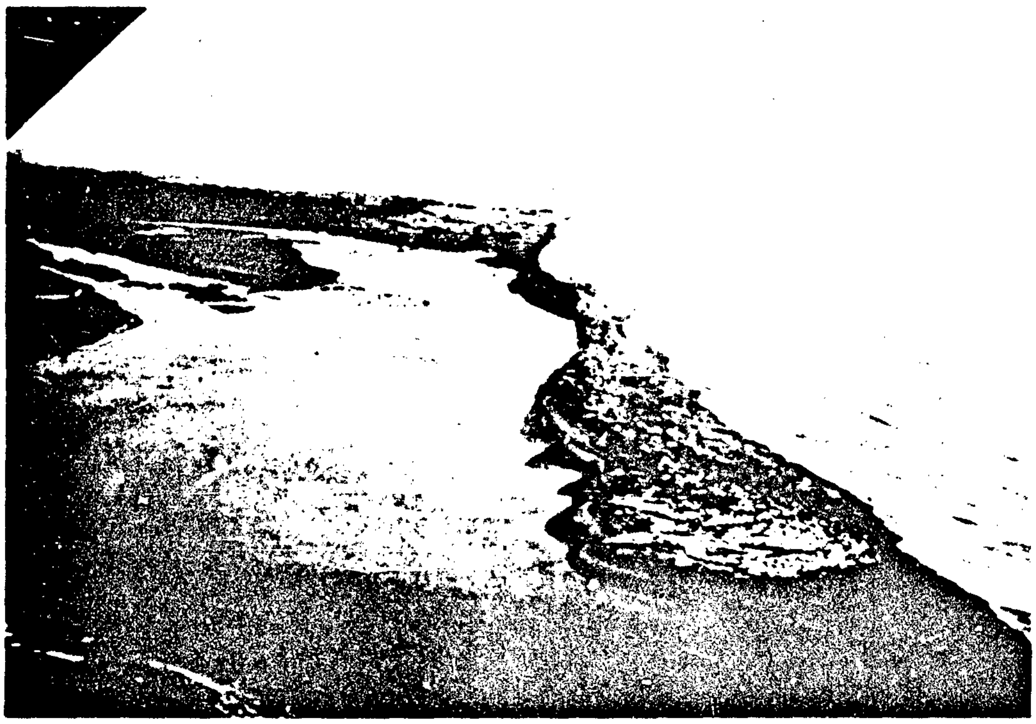


Fig. 13 Mouth of the Smith River showing sand bar. View to the south; note Castle Rock in background (August 1965).

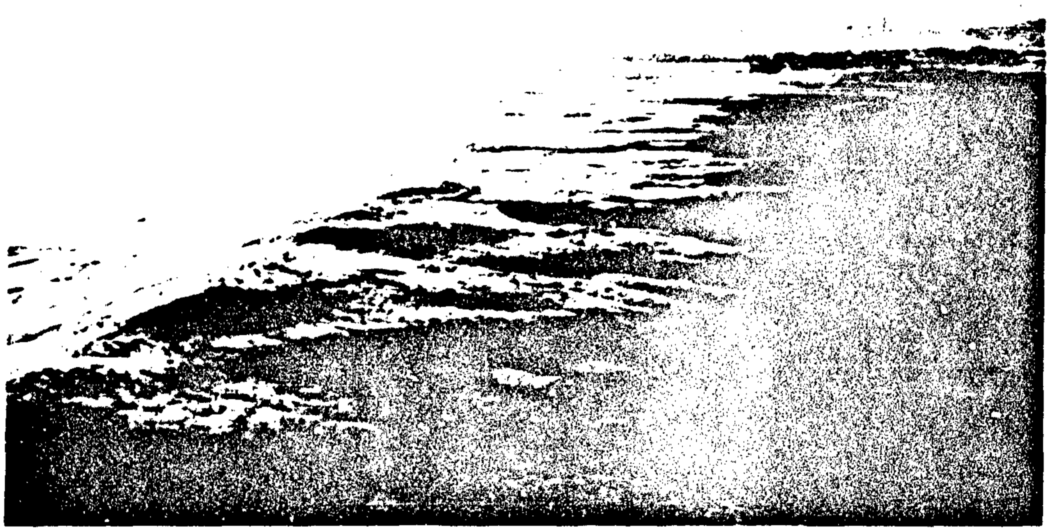


Fig. 14 Active dune fields north of Point St. George. View to the north (August 1965).

Fig. 15 Point St. George showing Jurassic seastacks. View to east over Pliocene formation backing Pebble Beach (August 1965).

common in winter, the summer matrix is fine sand. The St. George formation (Pliocene) outcrops along the beach.

Zone VII

Beaches are bedrock controlled. There are a number of relatively steep cliffs with small pocket beaches in the zone.

Zone VIII (South Beach)

South Beach is an arcuate sand deposit positioned between the eastern Crescent City Breakwater and the Coast Range. In profile, this beach is relatively wide (400 feet to 600 feet) and flat (1:50-100). Sediment ranges from fine to medium sand, but cobbles and coarse shell fragments are common, particularly in the southeastern one-half of beach. The major sediment source is a fluvial terrace immediately inland (Fig. 16).

Zone IX

South of South Beach the Coast Range parallels the shoreline (Fig. 17). Small pocket beaches occur in accordance with local conditions.

Zone X

The tenth zone is the region enclosed by the breakwaters forming Crescent City harbor.

In summary, the coastal characteristics along the Smith River Plain reflect a close correlation between (1) wave exposure, (2) bedrock influences, and (3) various sources of coastal sediment. Beaches range from narrow and small, coarse-grained pocket beaches to long, straight or arcuate beaches of sand and gravel.

Fig. 16 South Beach showing mouth of Cushing Creek near A. R. G. Beach Profile Site No. 7. View to northeast showing truncated Battery Formation (fluvial) (August 1965).

Fig. 17  Jurassic cliffs exposed along Structural Trend I. View to east showing one of the local sources of sediments for South Beach (August 1965).

## IV. EXPERIMENTAL TECHNIQUES

The primary objective of the study was to learn as much as possible about the long term and short term dynamics of coastal processes at South Beach (Fig. 18). To do so within the available funds necessitated the selection of optimum sites and required careful experimental design. These considerations are discussed in the following paragraphs.

### Site Selection and Description

Based on the findings of the regional analysis of the coastal zone, presented in Section III, seven beach profiles and two locations for beach grids were located on South Beach. A site for offshore study was selected so that it was directly offshore from one of the beach grids. These locations also coincide reasonably well with profiles monitored by the Corps of Engineers; their Profiles 3 and 4 were located specifically to overlap our central profiles.

#### Beach Profiles

Seven beach profiles were selected for study. Permanent benchmarks were set at each location. The elevation of each benchmark was determined, using the Coast and Geodetic Survey Benchmark, R-4R-BM-73. The establishment of the seven sites was for the following purposes:

1. To run beach profiles (five-foot intervals so a comparison would be possible at various seasonal periods)

2. To make a topographic map of the beach

3. To be used as a reference for fathometer profiles from shore to approximately 1.5 miles (statute) seaward.

#### Beach Grids

Sites 3 and 4 (ARG Profiles 3 and 4) were also selected as locations for beach grids. For the intensive study, the field part established three lines of grid rods at each site (Fig. 19). Lines 1 and 2 were spaced 100 feet apart and lines 2 and 3 were located 200 feet apart. Each line had 15 rods spaced 25 feet apart. Although the rods were taped with fluorescent tape, caution signs were necessary to prevent unusually heavy automobile traffic from disturbing the controlled experiment and also to assure safe conditions for pedestrians.

The purposes for the beach grids were:

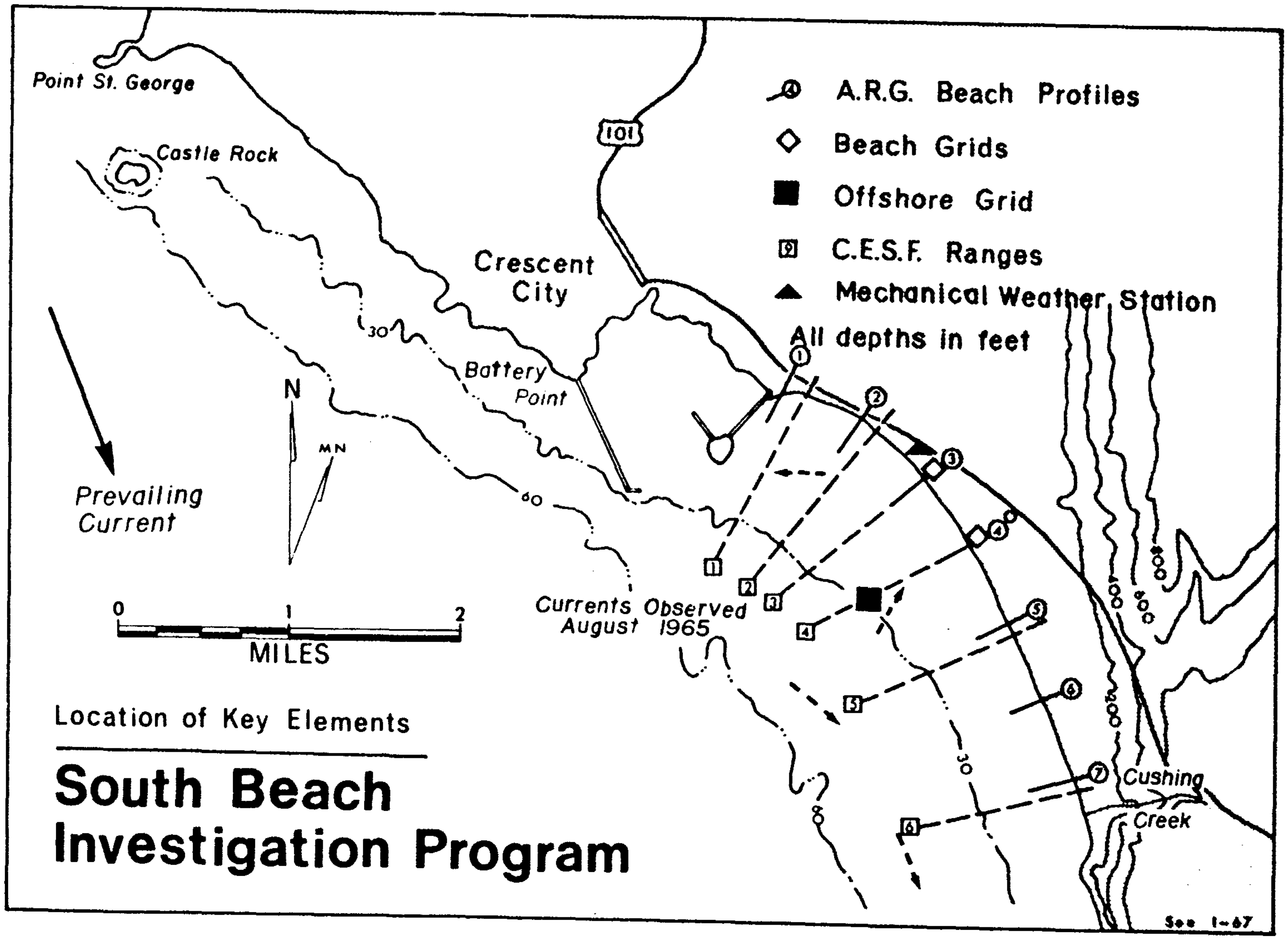

Point St. George
Castle Rock
Crescent City
101
Battery Point
30
60
N
MN
Prevailing Current
0
1
2
MILES
A.R.G. Beach Profiles
Beach Grids
Offshore Grid
C.E.S.F. Ranges
Mechanical Weather Station
All depths in feet
Currents Observed August 1965
200
400
600
800
Cushing Creek
Location of Key Elements
South Beach Investigation Program

Fig. 18

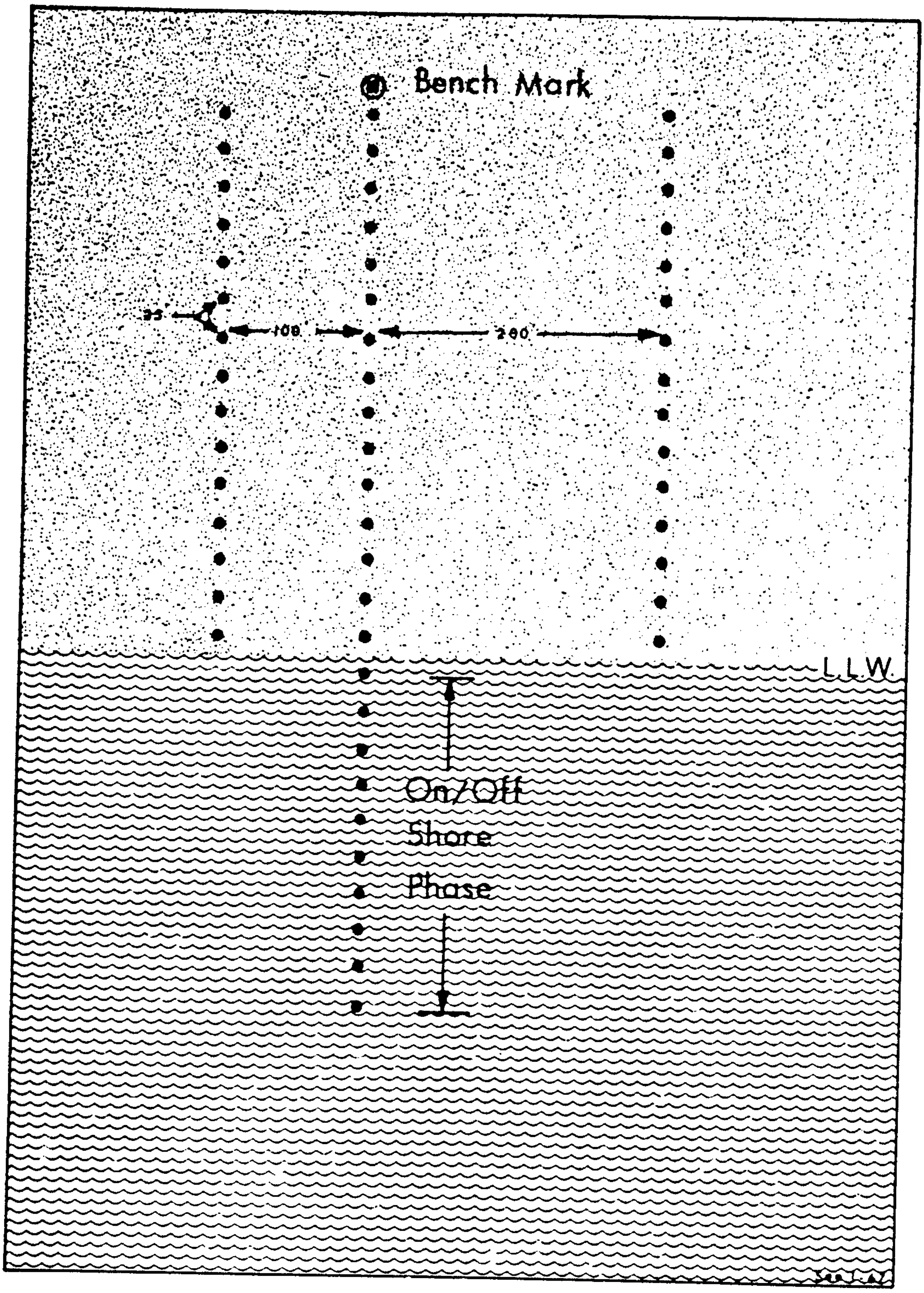



Fig. 19 CONFIGURATION OF BEACH GRID

1. To measure the sand displacement within tides, between tides, and between high energy-low energy conditions

2. To measure wave runup by using a stop watch to measure swash

3. To estimate approximate wave height

4. To estimate littoral current

5. To locate points for collection of sand samples.

Offshore Grid

A grid was established for SCUBA observations of sediment transport in water approximately 30 feet deep at low-low water. The grid was approximately one-quarter mile offshore and consisted of two concentric squares, 40 feet and 80 feet on each side, respectively (Fig. 20). Rods for the measurement of sand transport were placed at the corners of the grids, and a charge of sand dyed with spirit-soluble Uranine was placed in the center of the grid for diffusion studies. No significant results were obtained because of contamination of sampling slides.

Schedule and Procedures

The experiments on South Beach consisted of two primary subprograms, (1) seasonal profiling, and (2) intensive study; and one secondary subprogram, coordinated onshore-offshore study.

Seasonal Profiling

Each of the seven profiles was surveyed periodically from August 1965 through December 1966. Traverses were made at low tide with five-foot spacings between readings. Sediment samples were collected from the lower beach, midtide zone, and the berm.

Intensive Study

Two periods of intensive study were undertaken during the contract. During summer 1965, and winter 1965-1966, intensive study observations were made of (1) within-tide, and (2) between-tide beach dynamics.

In the summer period, beginning in mid-July, within-tide beach dynamics were measured on a tidal cycle (25 hours) for seven days. For two tidal cycles, measurements were taken at all rods on both grids at approximately three-hour intervals. For the remaining days, measurements were made approximately every six hours. The field crew

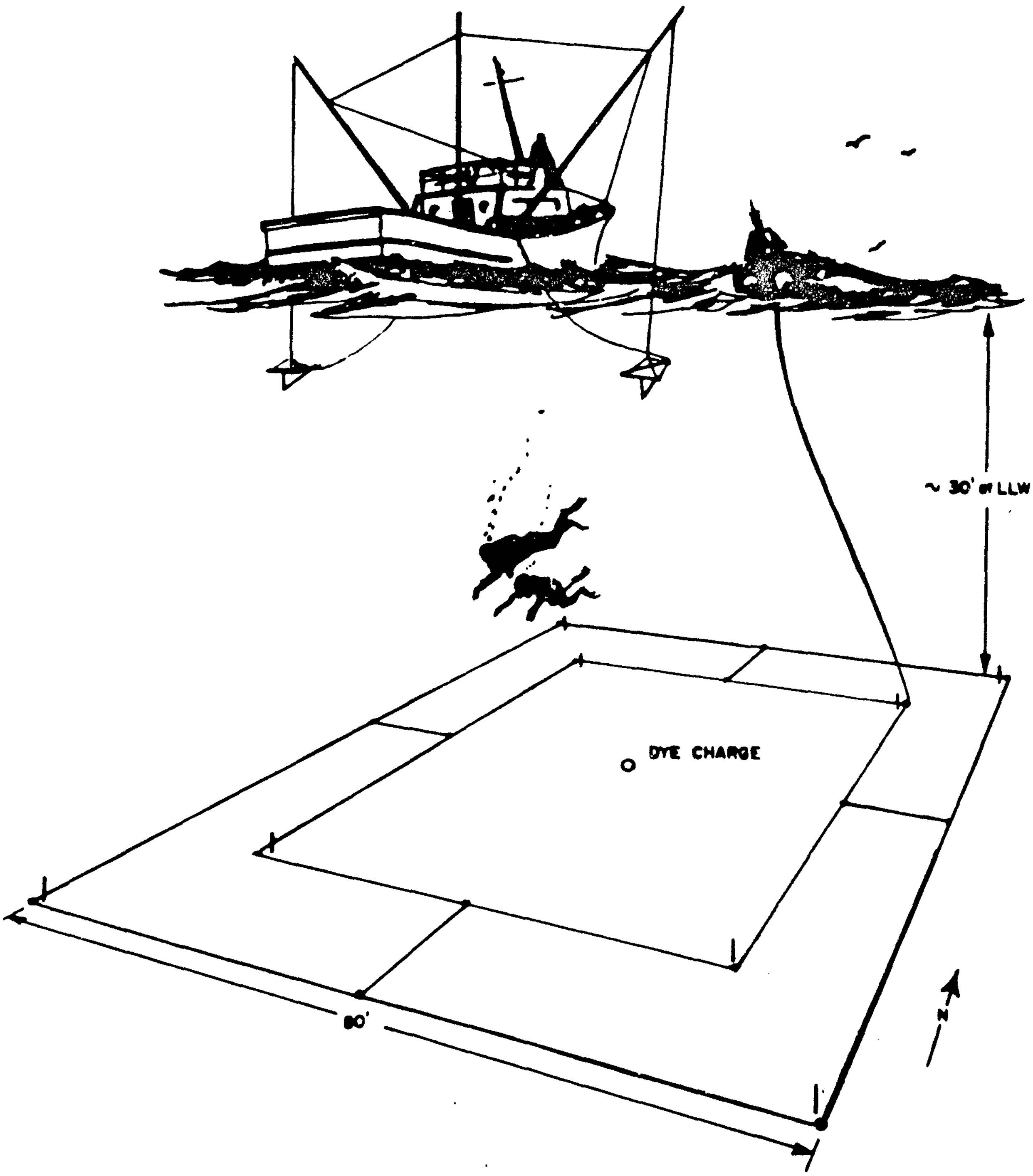



Fig. 20. CONFIGURATION OF OFFSHORE GRID

measured each rod with a hand held "slide-rule" (Fig. 21). The rods were repositioned at a premarked zero point after each measurement. During the winter period, within-tide observations were made approximately every six hours.

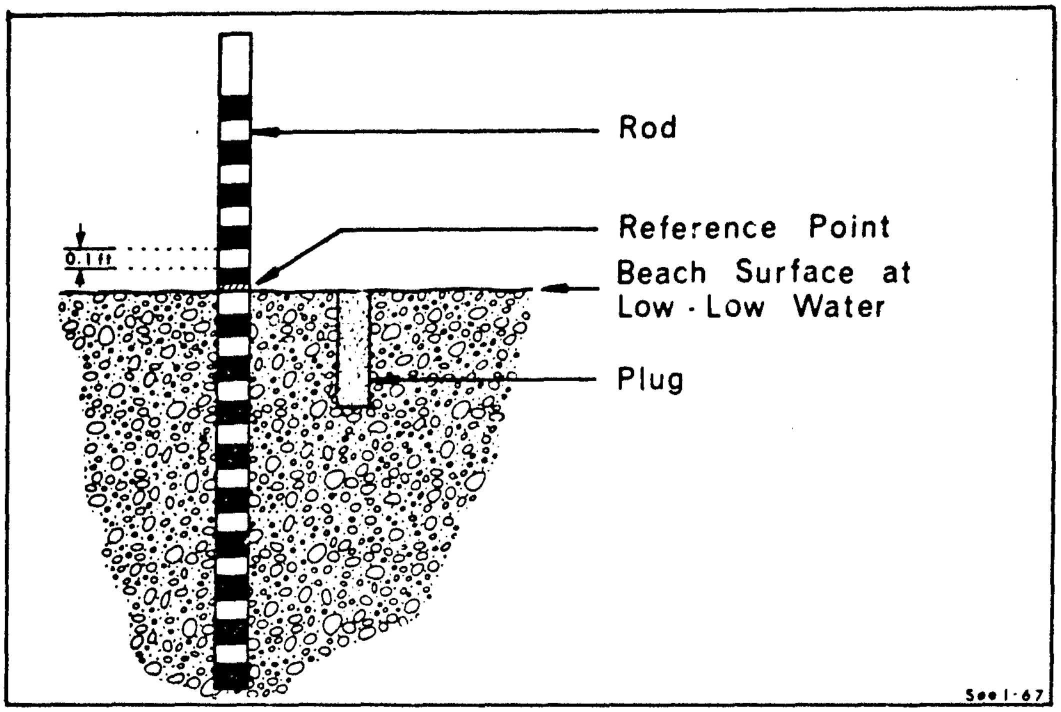
In summer 1965, between-tide observations of both grids were measured once each day at low-low tide. Profiles were resurveyed every three to four days. Sand plugs (white sand embedded into the beach as in Fig. 22) and littoral current measurements were made daily for the first two days and then every three or four days until mid-August. Observation of sand transport during the period of within-tide observation indicated that the movements did not warrant daily measurement for the entire period. Rods were measured as described in the previous paragraph.

Onshore-Offshore Coordinated Study

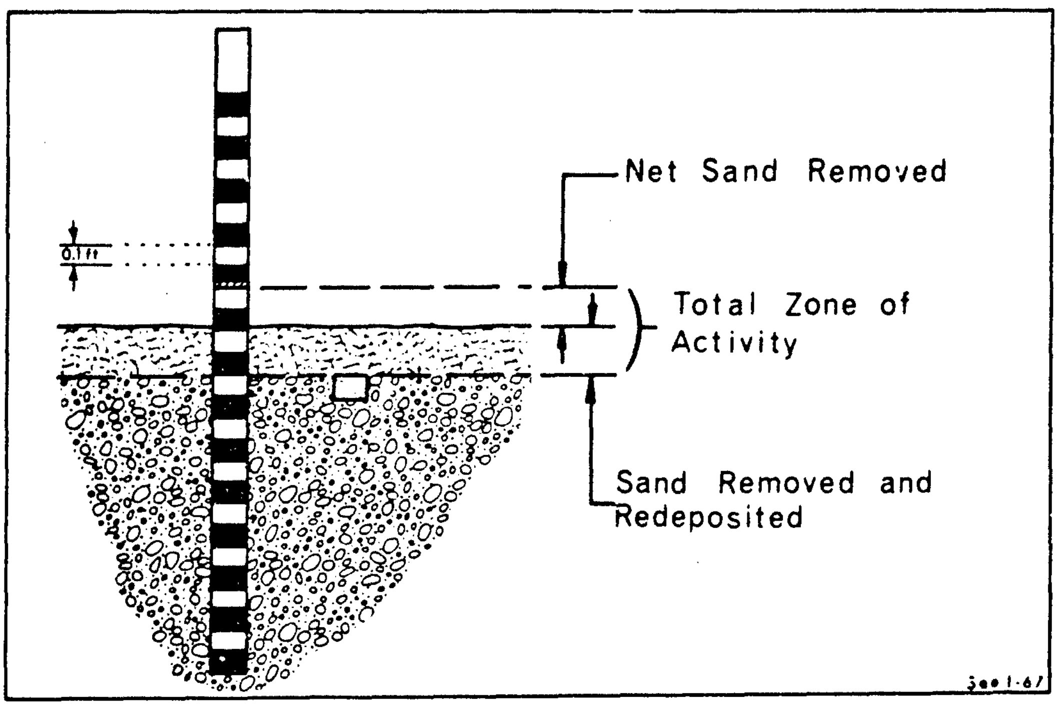
Concurrent with four days of between-tide observations on the subaerial beach in August 1965, underwater observations were taken during each tidal day on a six-hour cycle. The divers, using SCUBA gear,* measured and reset each rod by observing exposed taped sections (Fig. 23). They then took sand diffusion samples on silicone greased, plastic microscope slides. The slides were stored in airtight plastic boxes for subsequent laboratory analysis.

*SCUBA (Self-Contained Underwater Breathing Apparatus) operations were previously described in a paper entitled "Utilization of SCUBA Techniques for Sediment Transport Studies," presented at the Offshore Exploration Conference (OECON), 1966.

Fig. 21 The displacement of sand is measured for within-tide, between-tides and during high/low energy condition variations. Notice the swash zone, outer bar, and inner trough in background, and the grid rods, "slide rule" and measurement procedure in foreground (July 1965).




Sand plug at time of insertion




Sand plug showing typical situation at time of next reading

Fig. 22. SAND PLUG EXPERIMENT

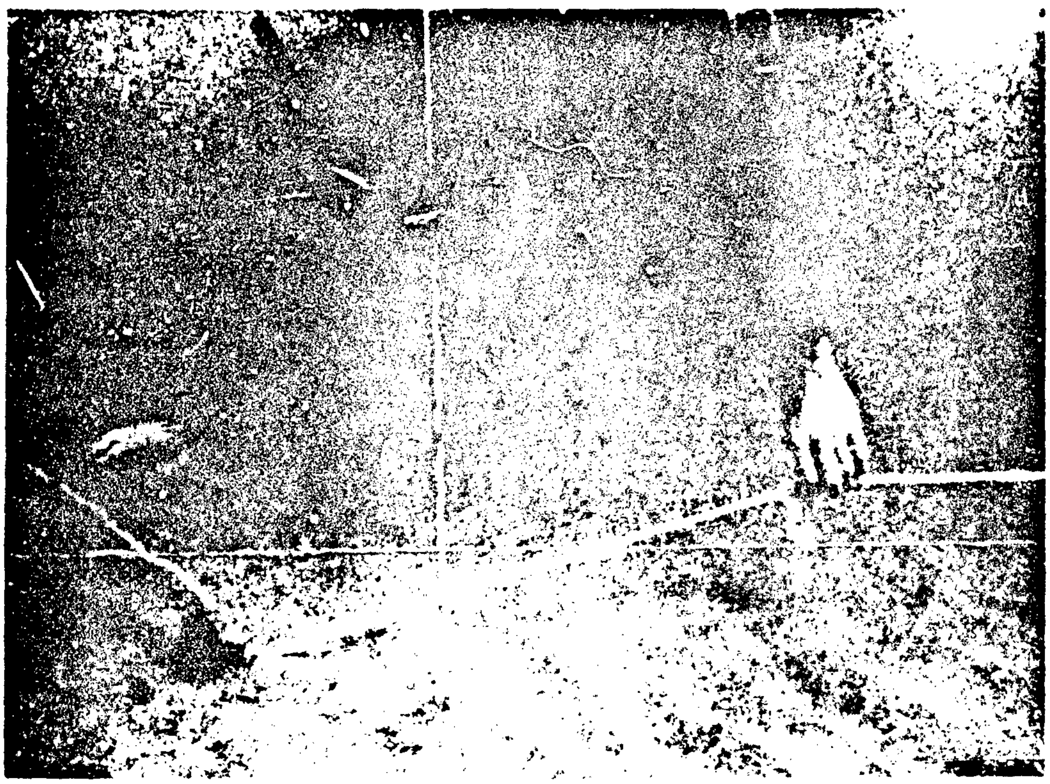


Fig. 23 Diver approaching sand measurement rod on offshore grid (August 1965).

## V. DYNAMICS OF SOUTH BEACH

### General Description

South Beach is an arcuate beach approximately four miles in length. As shown in Map 3, the beach consists of two primary subregions: the northwesterly half, which consists of a broad, flat beach backed by recent fluvial materials; and the southeasterly half, which consists of a beach backed by truncated fluvial material of the Battery Formation. The beach is terminated on the southeast by an exposed cliff of Jurassic material.

The beach is composed primarily of fine to medium sand containing a variety of minerals, principally quartz and rock fragments. The beach sediments are derived from Pleistocene terraces and minor amounts of fluvial material transported into the region by Elk Creek. Analysis of the sand samples taken during 1964 to 1966 between the lower beach and the berm reveal little coarse sand in the matrix. The pebbles and cobbles which are present in the southern zone of South Beach result from erosion of the truncated formation exposed in that zone. As a result, the beach sediments of South Beach are bimodal; both sand and cobble-pebble fractions are present and both are well sorted. The steepest part of the beach profile is near the berm crest while that section submerged during high tide is wide and flat. These characteristics vary only slightly throughout the year.

Although beyond the scope of the study, some offshore work was conducted using fathometer traverses and diving operations by ARG personnel. Additionally, some foreshore information was collected from the U. S. Army Corps of Engineers, San Francisco District Office. The profiles made by the latter agency are presented as Figs. 24 through 29.

During much of the summer season there is an inner trough and a well developed bar (Fig. 30). From the crest of the bar the slope seaward is very gradual and the bottom is relatively featureless. About 1500 to 2000 feet offshore, at approximately the 20-foot to 30-foot depth contour there is a bedrock scarp. Initial analysis of this scarp leads to the conclusion that it is associated with Structural Trend III, described in Section II. Although this break in the offshore slope was easily detected and can be seen in Figs. 25 through 29, the exact role it has in the modification of incoming waves was not established during this study nor is it immediately apparent from the refraction charts in Section III.

### Seasonal Beach Variability

The results of the experiments conducted on South Beach indicate that the beach is cyclic in nature, building seaward during the summer and

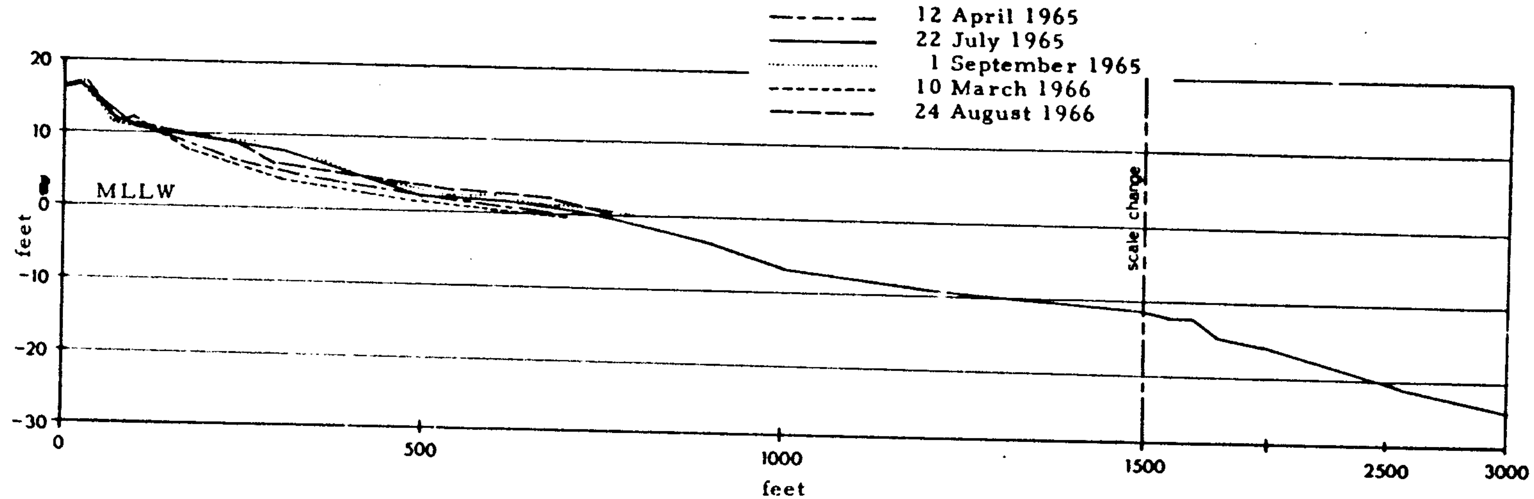



Fig. 25. CESF RANGE 2

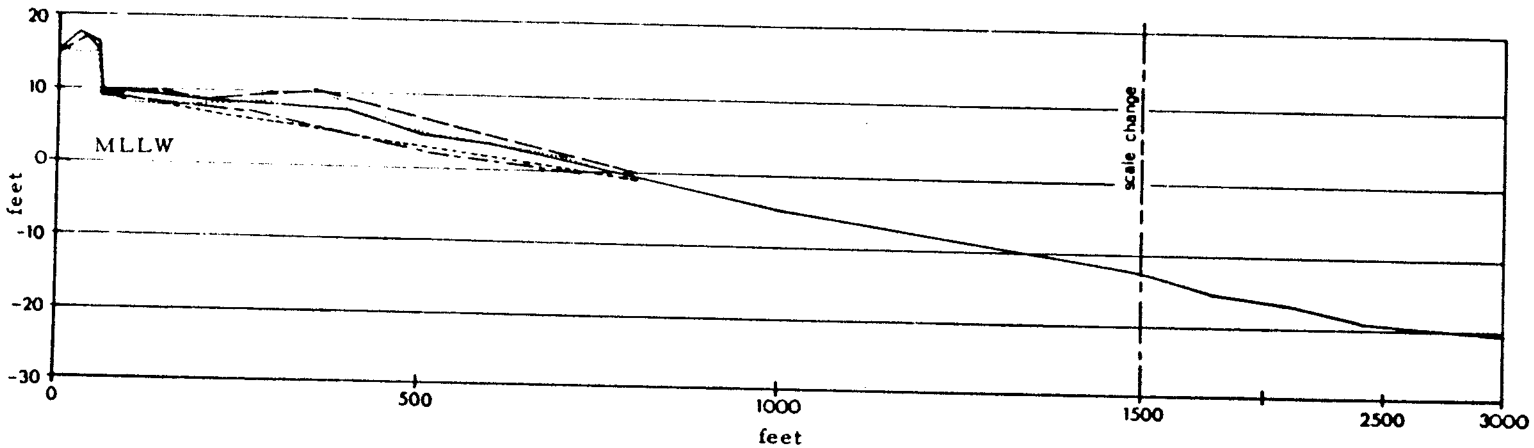



Fig. 24. CESF RANGE 1

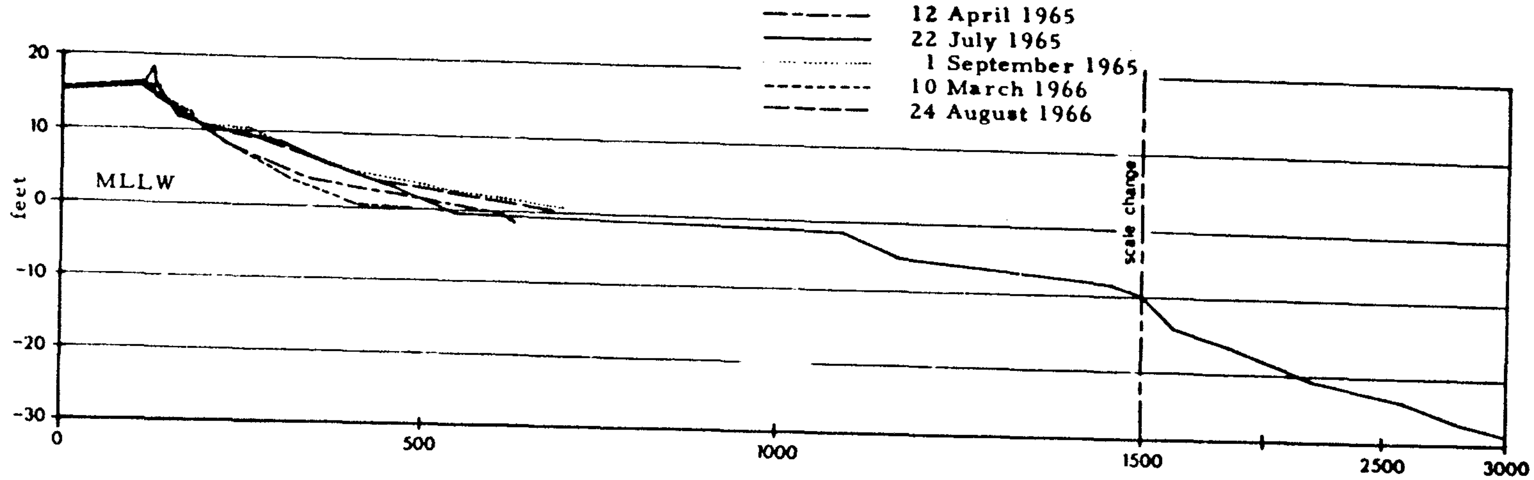



Fig. 27. CESF RANGE 4

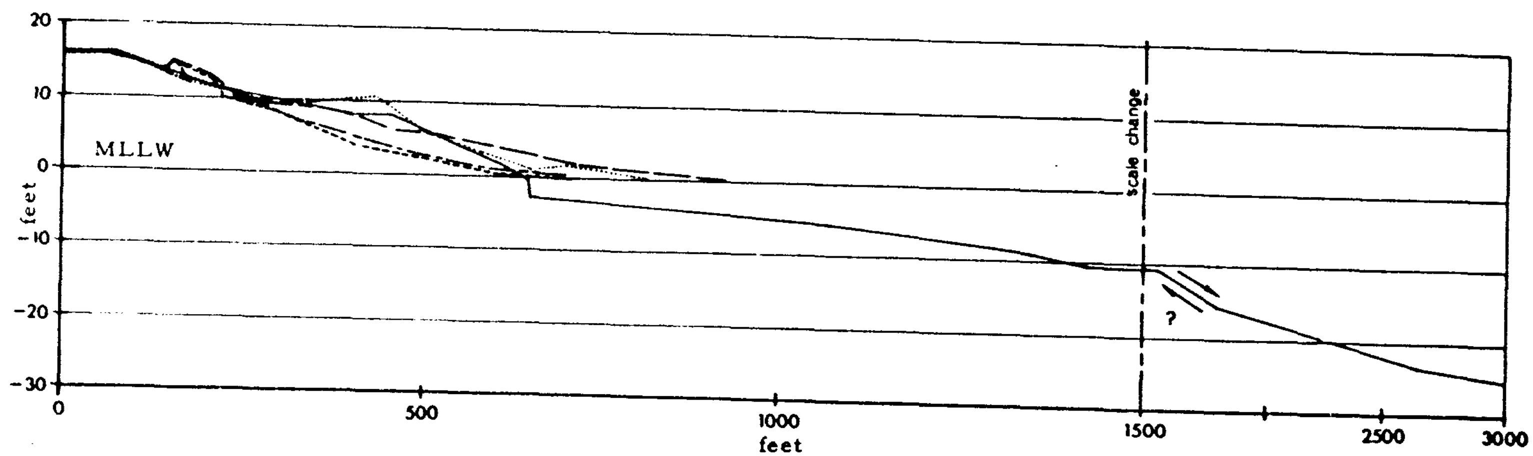



Fig. 26. CESF RANGE 3

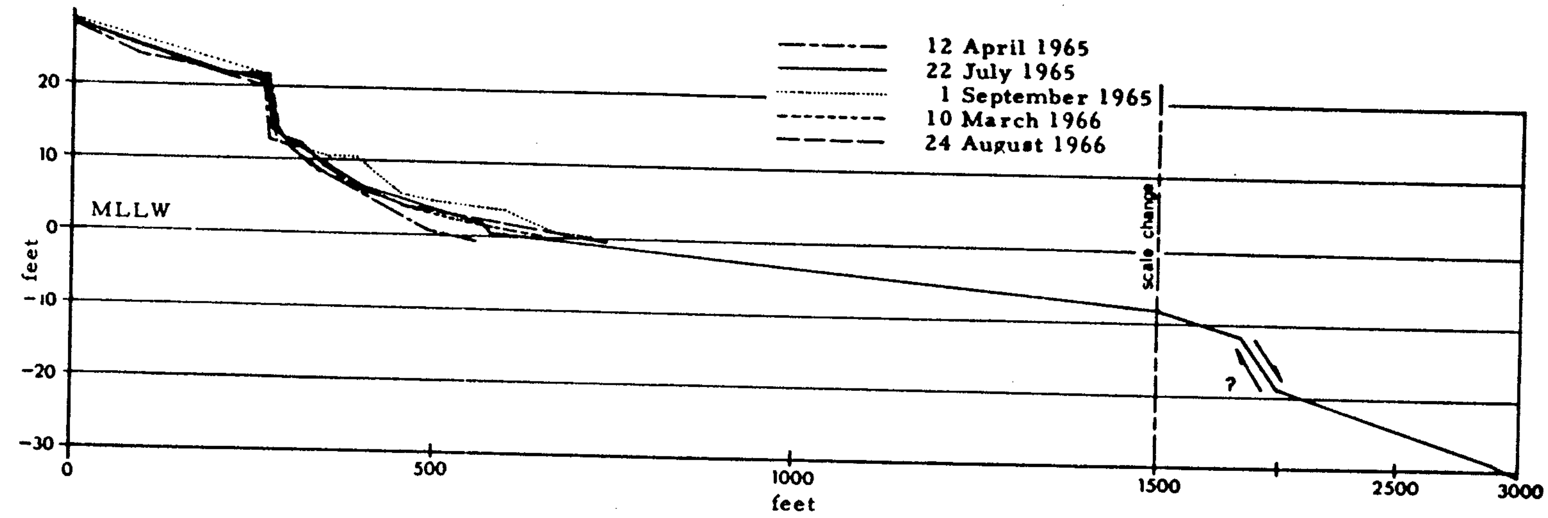



Fig. 29. CESF RANGE 6

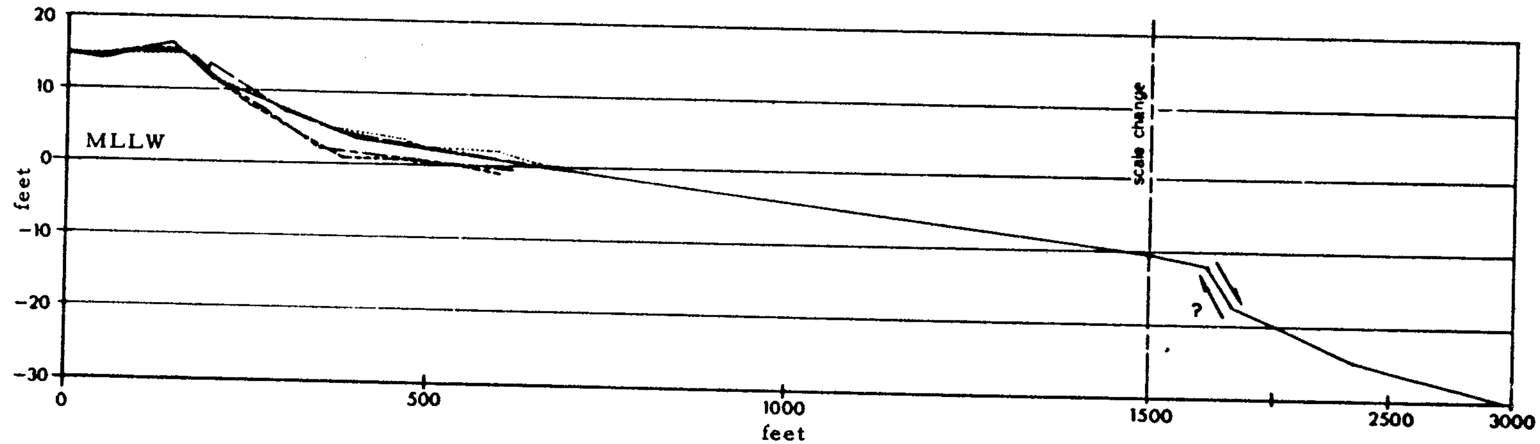



Fig. 28. CESF RANGE 5

Fig. 30 Trough and bar at Site 3 during low, low tide at South Beach. View north, northwest toward Crescent City (August 1965).

retreating landward in response to winter conditions.* The magnitude of change at the most active area on the beach, about seven feet between the greatest summer maximum and the lowest winter minimum, is small when compared to beaches elsewhere in California. **

### Beach Morphology

Figures 31 through 37 summarize sand level changes observed along the seven profiles during the study. The profiles reflect the magnitude of sand level change occurring during the study period and clearly reflect the seasonal trends of South Beach. December through April, the season of maximum wave energy, is the season of maximum beach variability (Fig. 38). Conversely, from May through November (Fig. 39), the beach reflects some variability (Refer to Fig. 37 which shows a summer variation of about five and one-half feet during the study). The most frequent changes during the summer are the results of the tide, the range of which was about 10 feet (-2. 0 to +8. 0), and the response of the beach thereto as discussed below.

Figures 40 and 41 present standard deviation of the seasonal profiles at Site 4 during summer and winter observations, respectively.

### Sediment

The results of the seasonal sediment analysis are shown with the profiles (Figs. 31 through 37). In General, only minor variations in grain size occur in the sands of South Beach. The beach material is biomodal in character, particularly in the winter season. Specifically, it appears that during periods of highest wave energy cobbles and pebbles are winnowed out of the backshore terraces. Concurrently, the finer sand portion of the matrix is moved offshore. Thus the coarse fraction is a lag deposit that varies with the seasonal character of waves and currents (Fig. 42).

---

*Appendix B presents a tabulation of the seasonal and short-term tidal variability measurements.

**Bascom (1964), Shepard (1963), Wiegel (1964), and the Corps of Engineers, San Francisco District Office [CESF] (1965) summarize the seasonal characteristics of the profiles of a large sampling of beaches throughout California. In the greatest number of cases the winter profiles exhibit changes of more than eight feet. One beach reported in the CESF report, Shelter Cove, which has a regional exposure similar to South Beach, reflects relatively stable conditions (about six feet).

Bascom also describes the effects of a protecting headland on beach slope and sand size at Half Moon Bay but does not include seasonal analysis of that effect.

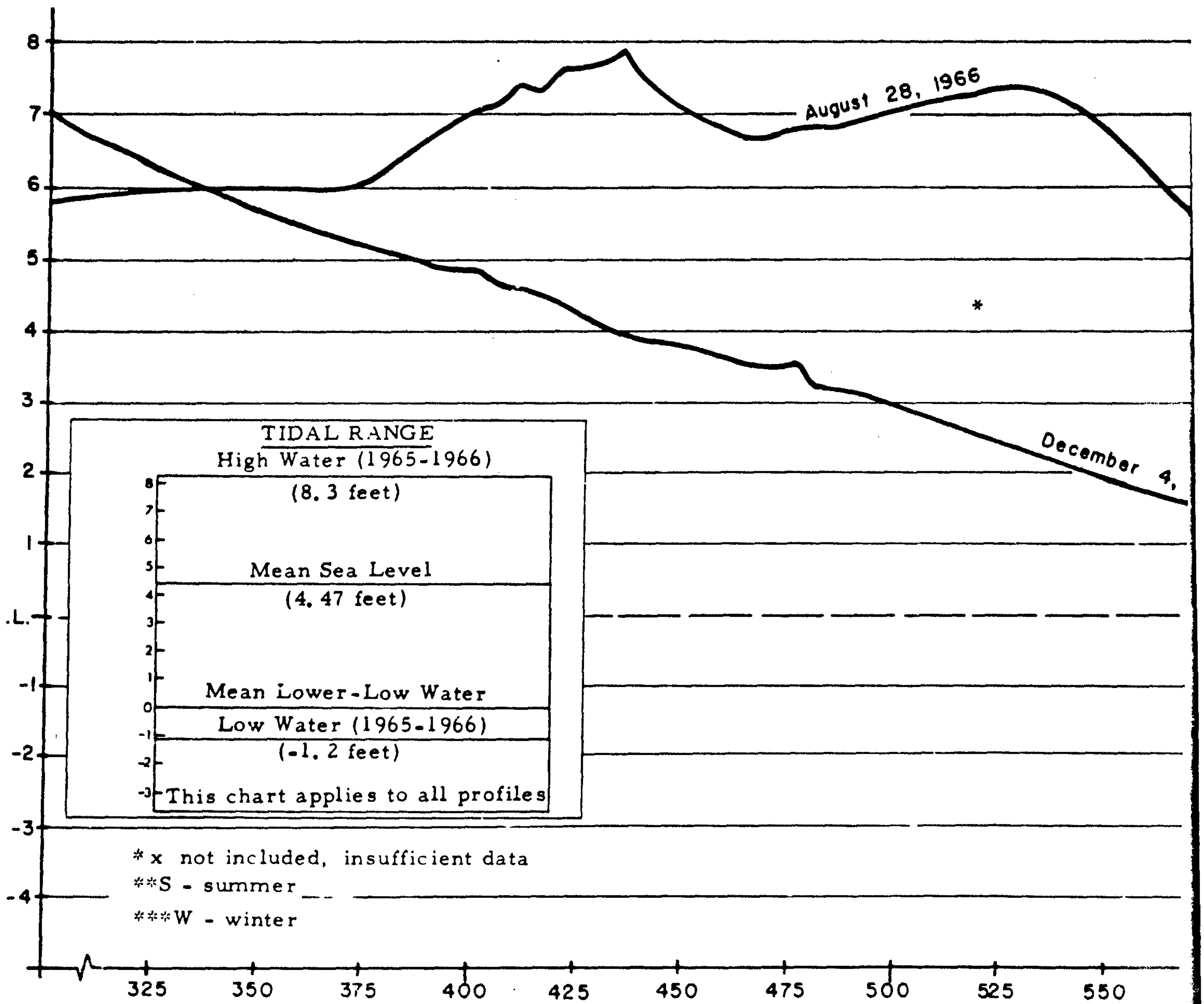
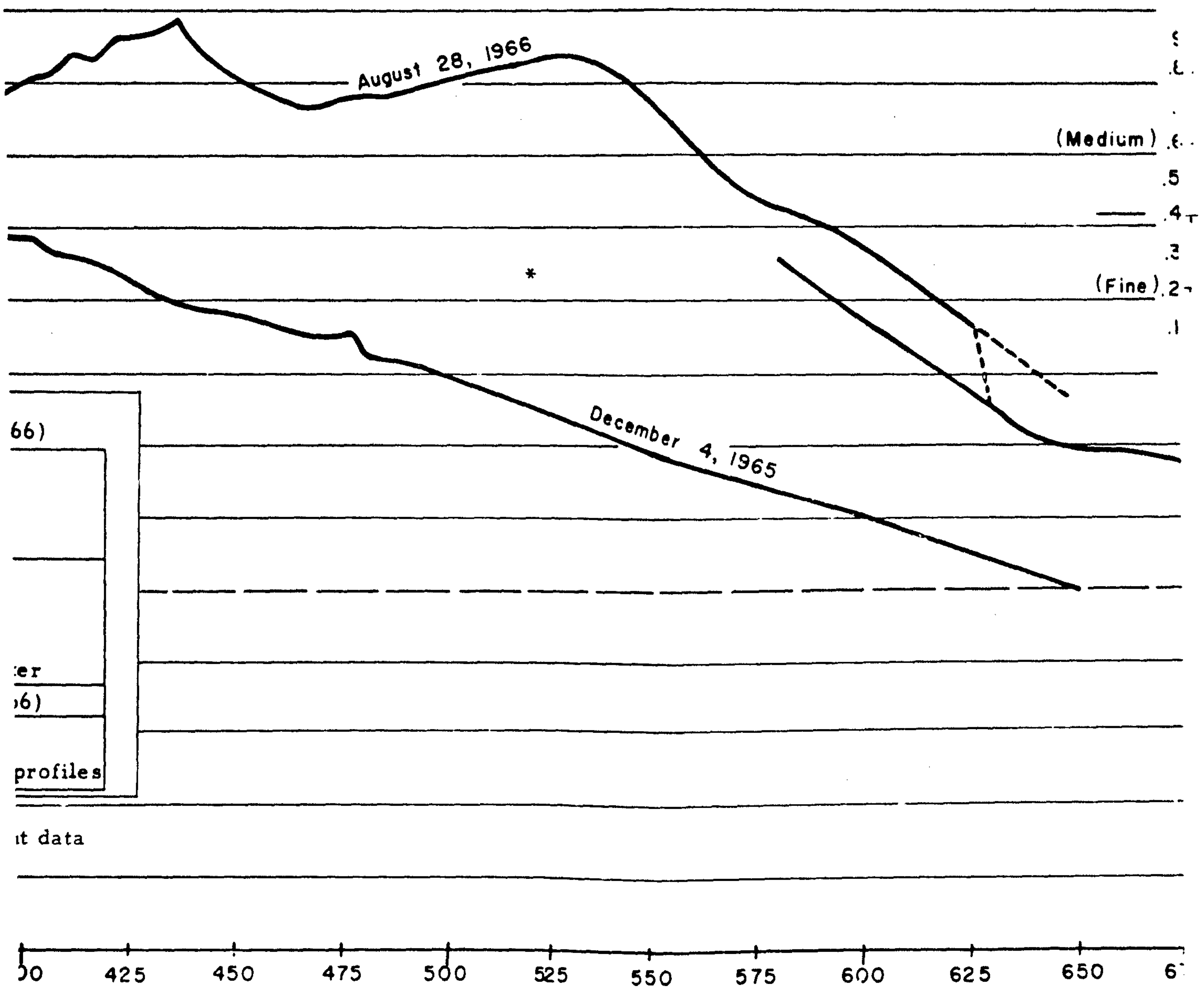


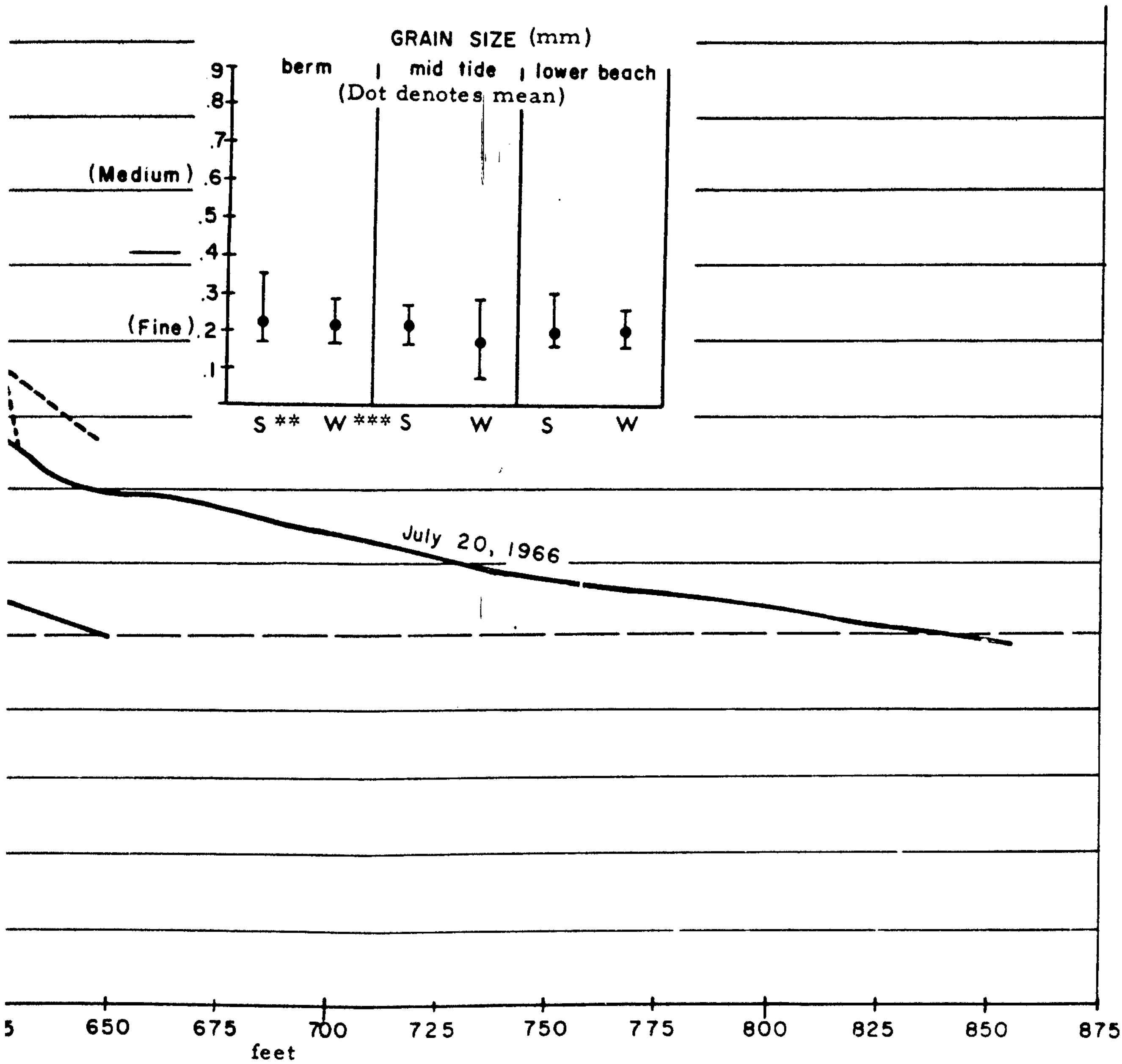

Fig. 31. SUMMARY OF SEASONAL PROFILES AT SITE 1



H




SUMMARY OF SEASONAL PROFILES AT SITE 1


GRAIN SIZE (mm)
berm
mid tide
lower beach
(Dot denotes mean)
(Medium)
(Fine)
.9
.8
.7
.6
.5
.4
.3
.2
.1
S **
W ***
S
W
S
W
July 20, 1966
650
675
700
725
750
775
800
825
850
875
feet

C

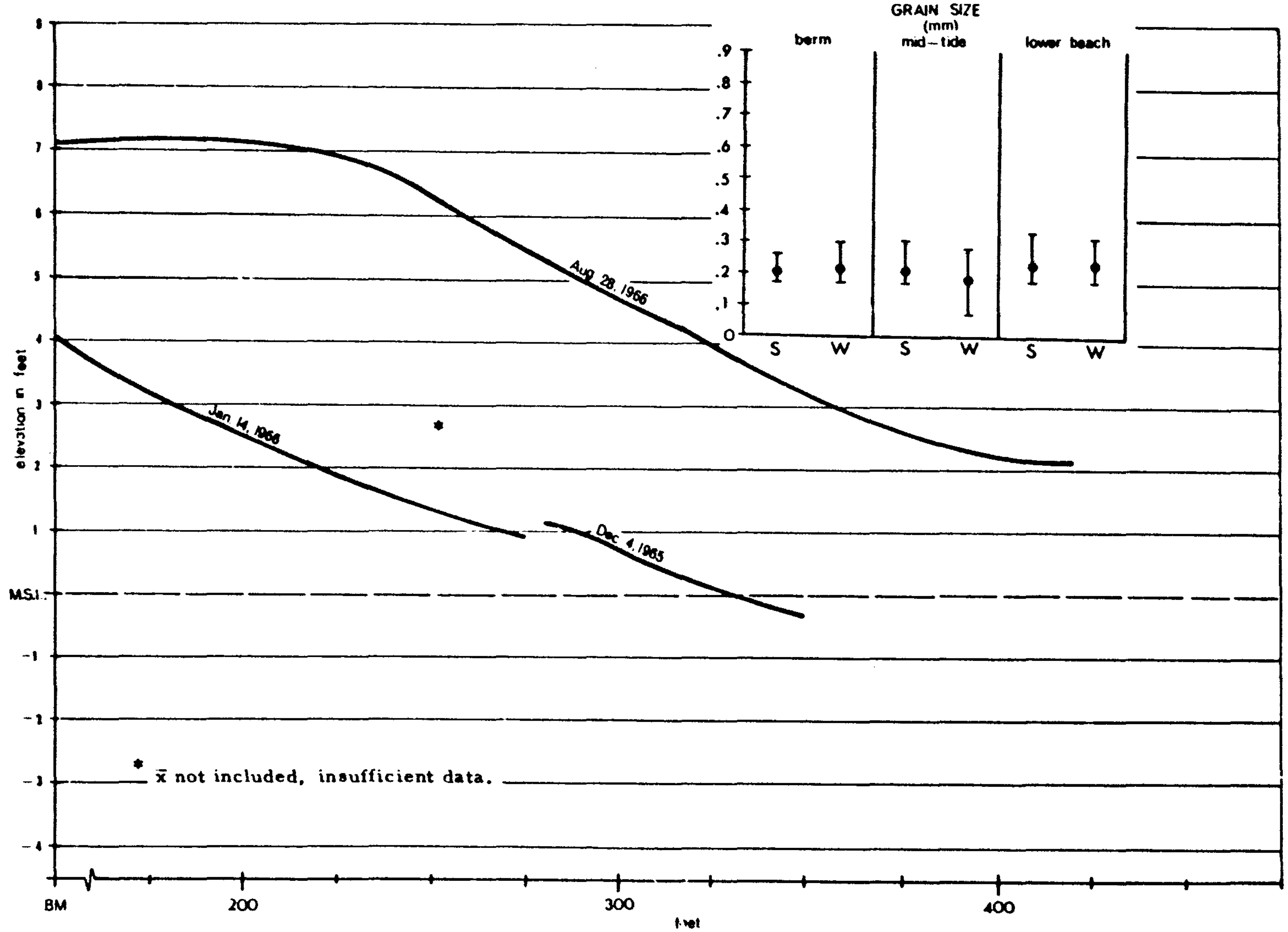



Fig. 32. SUMMARY OF SEASONAL PROFILES AT SITE 2

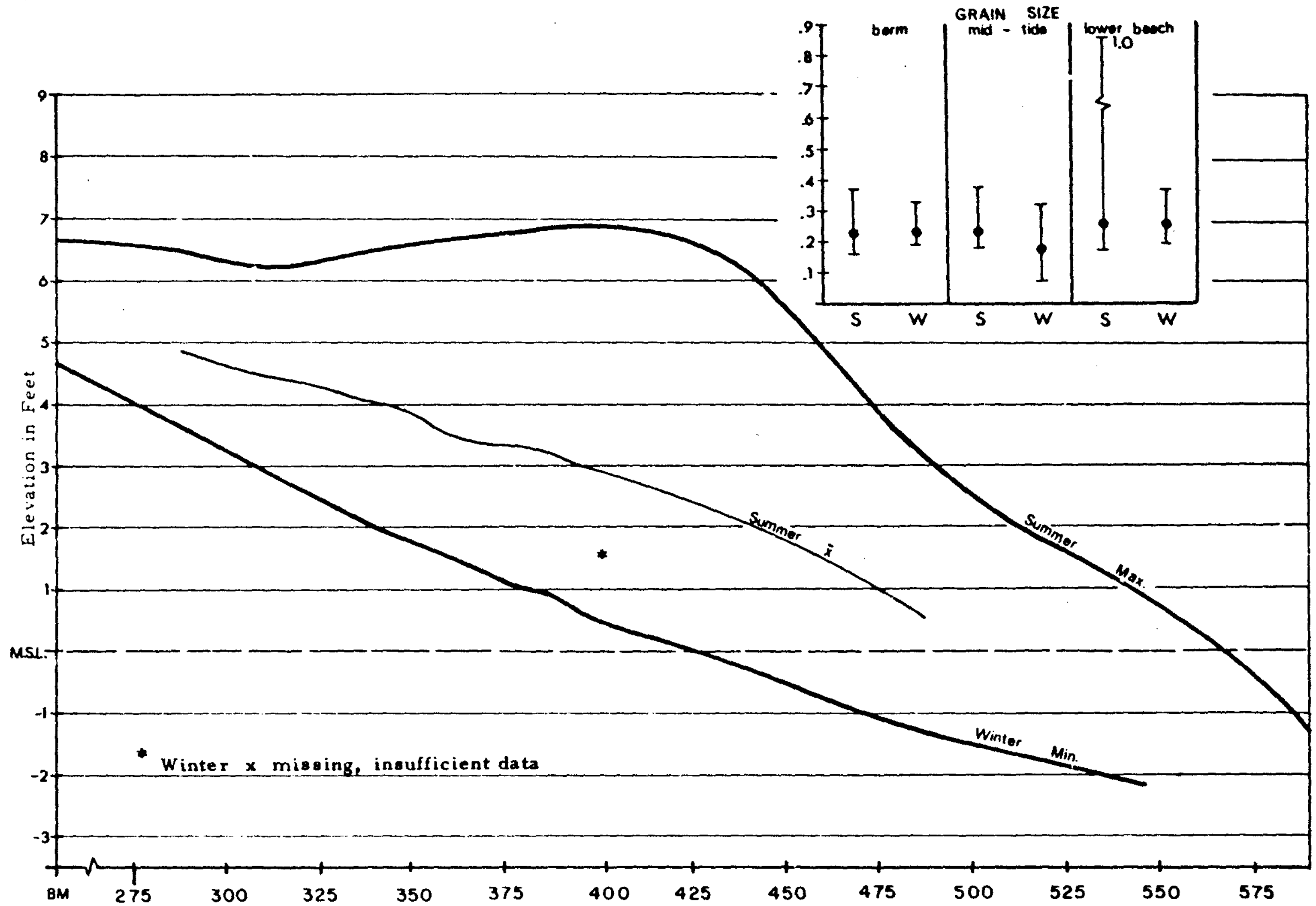



Fig. 33. SUMMARY OF SEASONAL PROFILES AT SITE 3

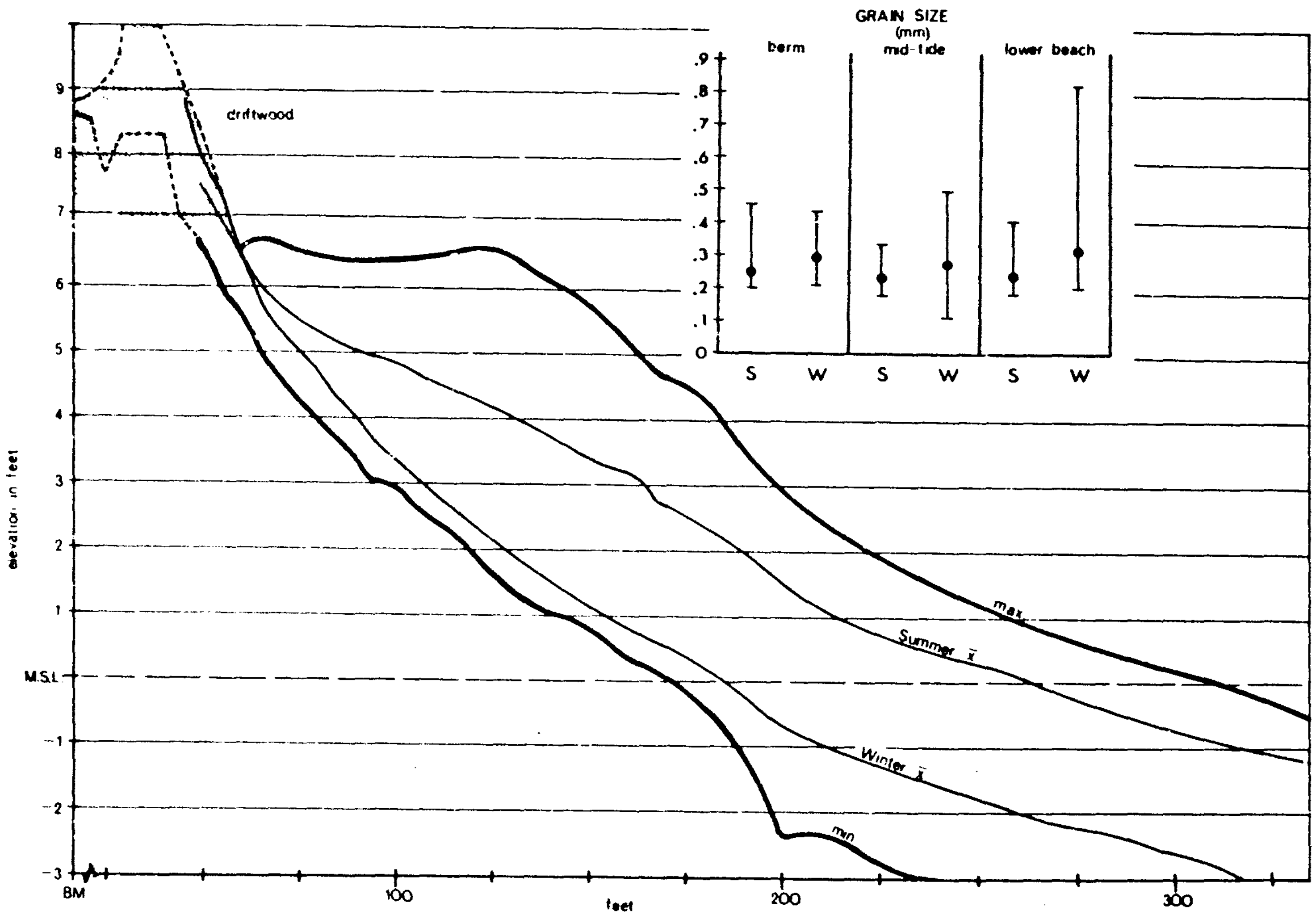



Fig. 34. SUMMARY OF SEASONAL PROFILES AT SITE 4

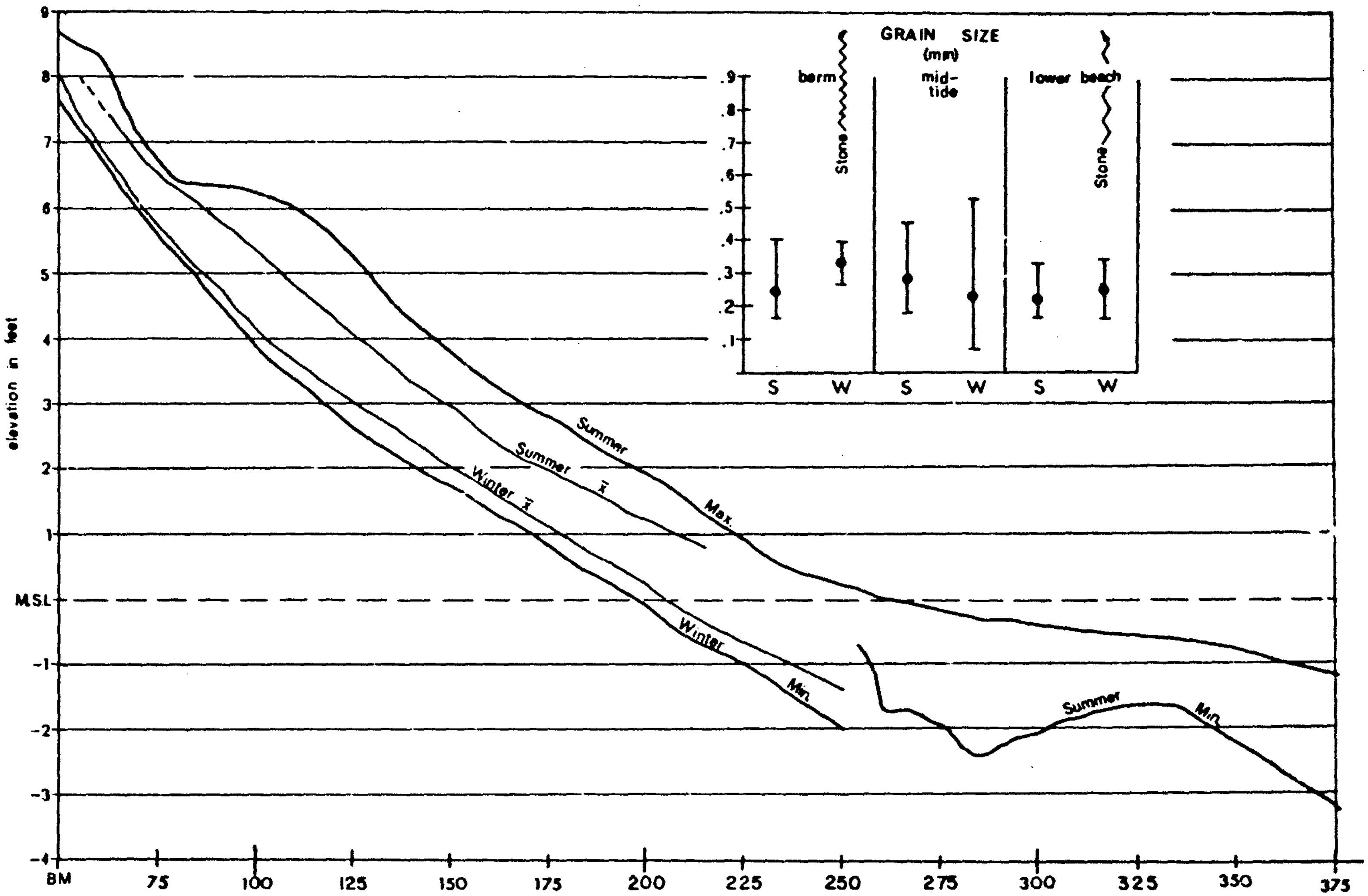



Fig. 35. SUMMARY OF SEASONAL PROFILES AT SITE 5

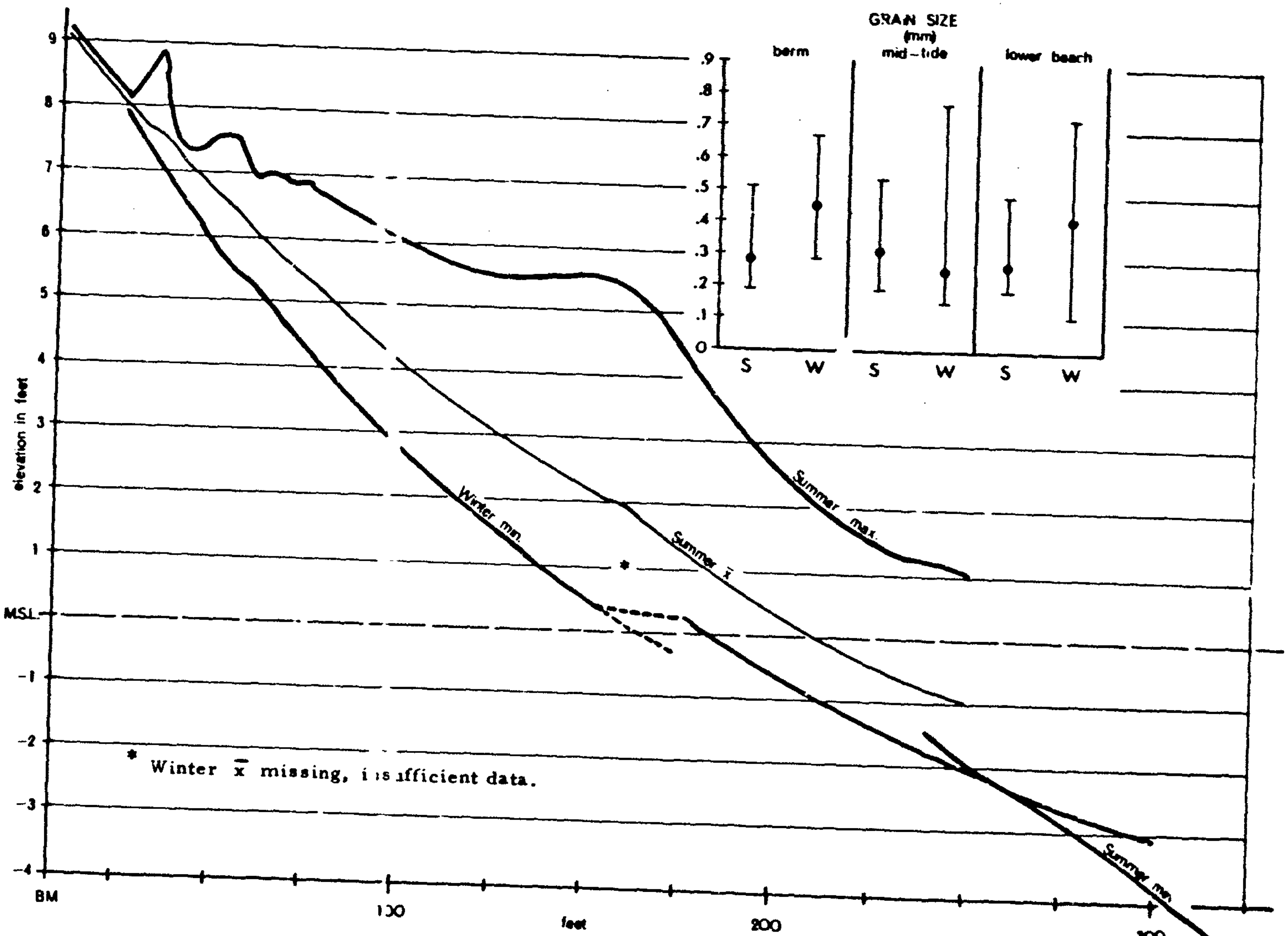



Fig. 36. SUMMARY OF SEASONAL PROFILES AT SITE 6

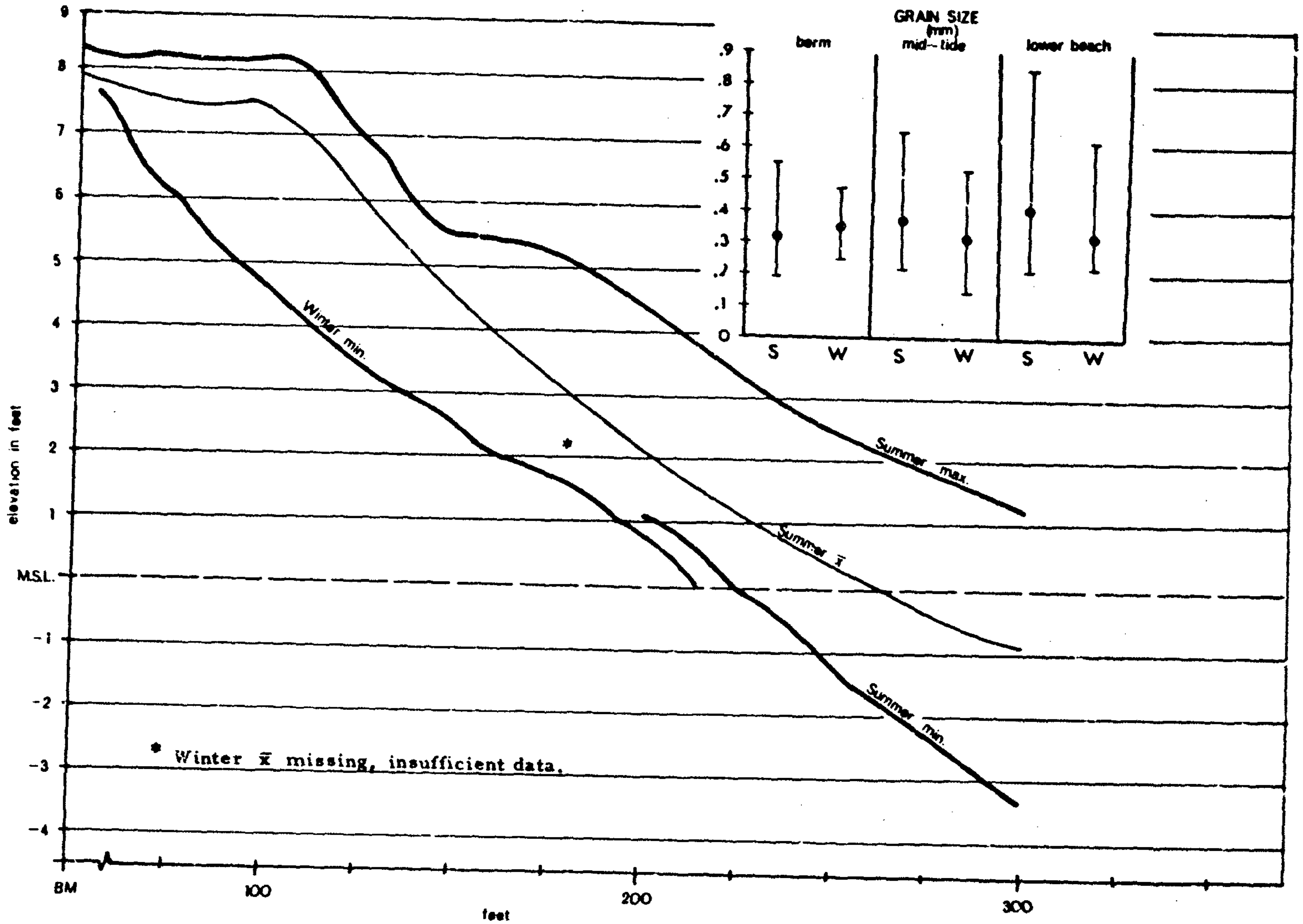



Fig. 37. SUMMARY OF SEASONAL PROFILES AT SITE 7

Fig. 38 South Beach at low, low tide at Site 4 showing bimodal sediment matrix. View north, northwest toward Crescent City (December 1965).

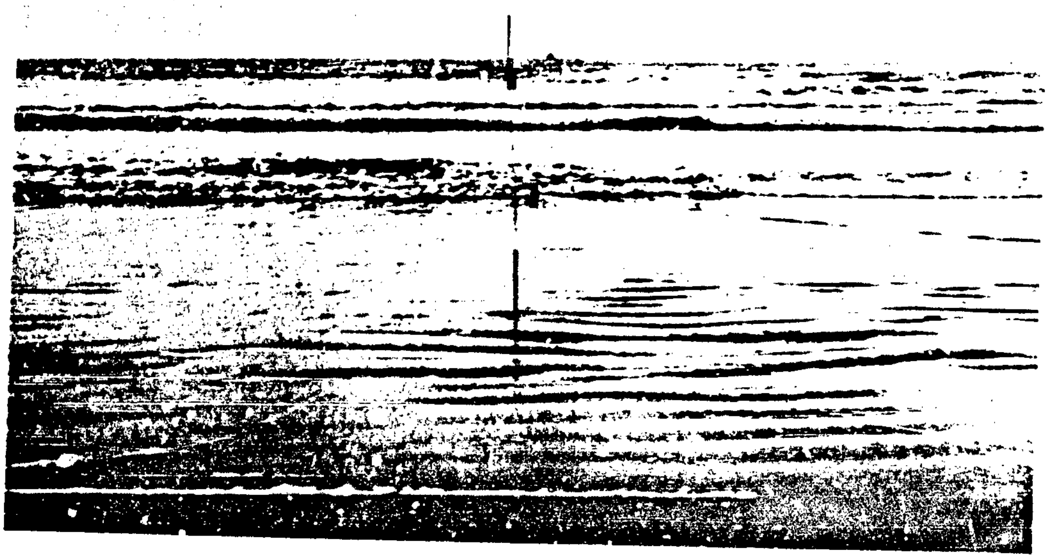


Fig. 39 South Beach at low tide illustrating low energy wave conditions and relationship of the submarine experiment to the subaerial experiment (August 1965).

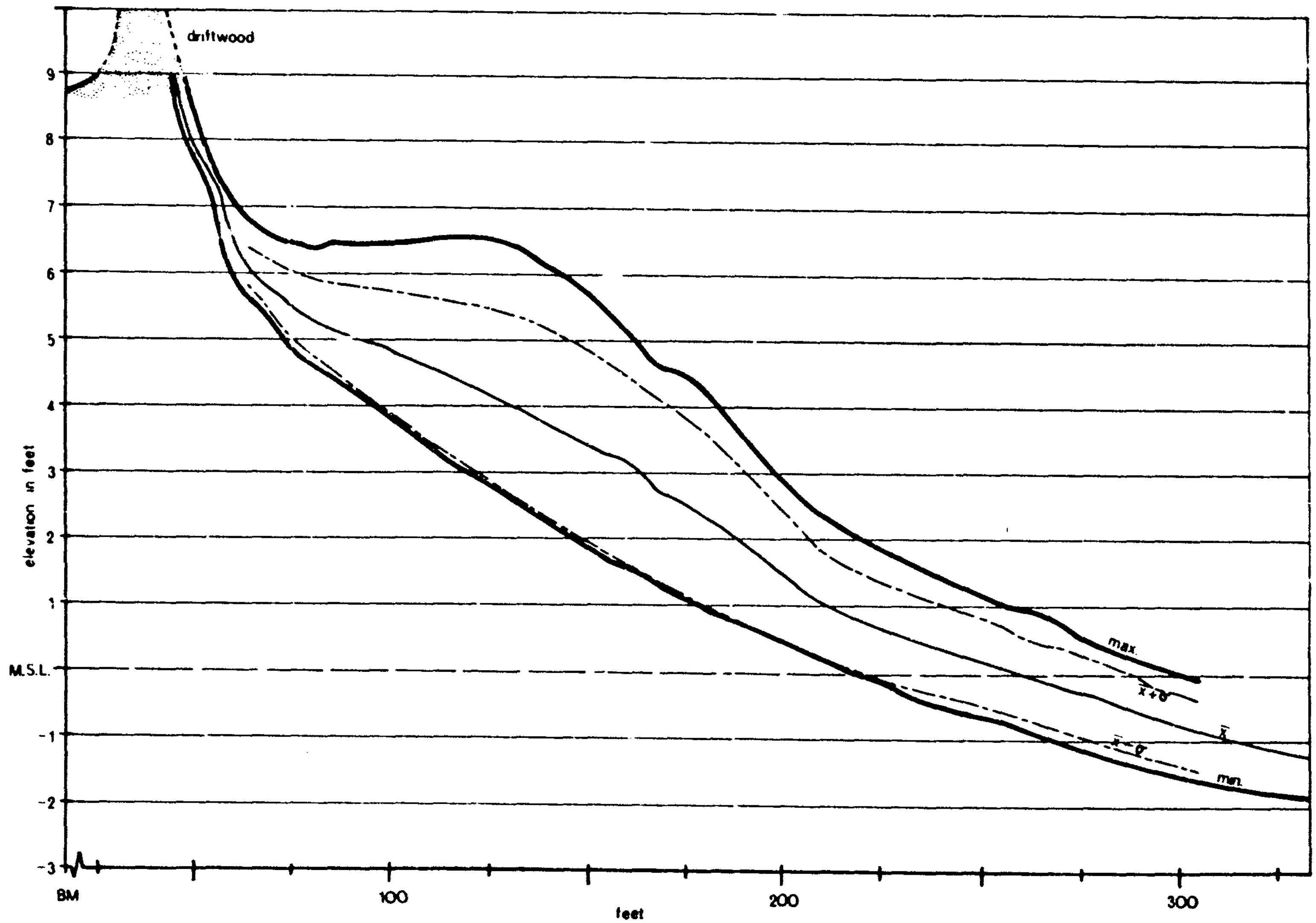



Fig. 40. LETAILED SEASONAL PROFILES, SITE 4, SUMMER

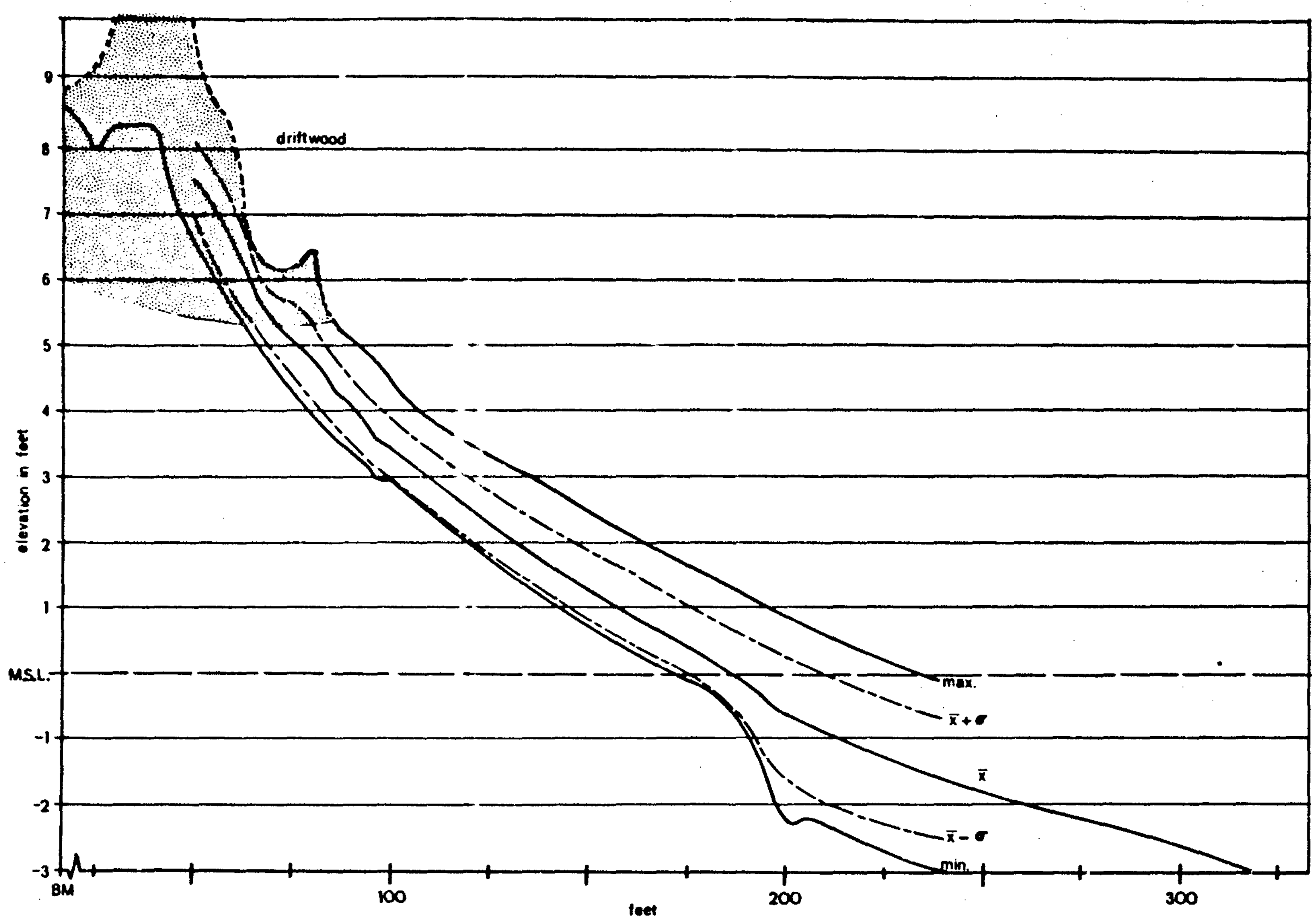



Fig. 41. DETAILED SEASONAL PROFILES, SITE 4, WINTER

Fig. 42 Erosion along small creek outwash near Site 4 showing bimodal character of the beach matrix in winter (December 1965).

No significant change was observed in the mineralogy of the beach sediments. The composition of the beach material was consistently about as listed in Table I.

TABLE I

BASIC MINERALOGY OF SOUTH BEACH SEDIMENTS*

| Material | Percentage | |
|---|---|---|
| | Summer | Winter |
| Quartz | 35 | 35 |
| Rock Fragments: | 35 | 41 |
| Metagraywacke<br>Greenstone<br>Chert<br>Quartzite<br>Chlorite Schist<br>Granite (?) | | |
| Shell | 5 | 14 |
| Epidote | 3 | ** |
| Olivine | 5 | 4 |
| Rutile | 5 | 3 |
| Siderite | 3 | ** |
| Others: | | |
| Magnetite, Ilmenite, Sphene (?) | 9 | 3 |

* From samples taken at midtide on Profile 4

** Included in "others".

The mineralogy of South Beach suggests that the sediments are of local sources, primarily the Pleistocene materials backing the beach and the Jurassic material immediately south of the beach. (Details of sample analysis are included in Appendix C.)

Short-Term Tidal Beach Variability

As stated previously, the objectives of short-term beach variability experiments were to detect changes in beach configuration and sediment characteristics which might be associated with processes controlled by the tides.

### Within-Tide Variations

Within-tide variations probably do occur on South Beach. However, despite the care in design of the experiment, the within-tide data are considered to be statistically invalid because the grid rods were "pulled" or bent by driftwood or other causes. The exact cause of their being "pulled" is unknown, although it may be associated with vibrations of the rods themselves. The cause of their being pulled or bent by driftwood is quite evident from Fig. 43.

### Between-Tide Variations*

Between-tide variations at ARG Profile 4 were of greatest magnitude during the summer. These variations are shown in Fig. 44. The largest changes occurred in the berm and trough zones. Between-tide variations in winter are much less pronounced than in summer, as illustrated in Fig. 45. In winter the largest changes occur in the same zones as in summer.

Figures 46 and 47 also show the between-tide variations along Profile 4 during the intensive study periods in summer and winter. In this case, however, the dynamics of each point along the profile are illustrated as a function of height versus time, height of high-high tide, and wave height. Inspection of the summer information (Fig. 46) shows a period of complex activity during late July 1965, coincident with the highest tides. Another period of significant activity took place during the four-day period 10-13 August 1965, when a storm passed through the area. The winter period of observations took place during the highest annual tides and a relatively constant level of wave height.

### Observations from Onshore-Offshore Coordinated Study

The data collected during the brief SCUBA experiment in summer 1965 were not conclusive. But when considered with respect to the excellent information collected on the subaerial beach, the data indicate a relationship between the responses of the subaerial and submarine beach to wave energy conditions.

---

*Since measurements of the beach change were replicated along several parallel lines, statistical tests of the analysis of variance were used to determine whether observations could be combined into a single set of measurements for each site. The results indicate that sand level variation and beach sediment variation between lines,within sites was insignificant. Therefore, the results of the experiments conducted along South Beach suggest that changes in configuration and sediment along the beach are uniform in response to within-tide and between-tide variations. As a result, only a single line at a single site is necessary to illustrate between-tide variations.

Fig. 43 South Beach at high tide at Site 4. View northward along berm toward Crescent City. Note results of log movement on beach in the bending of the six-foot, one inch pipe used as a benchmark in summer (December 1965).

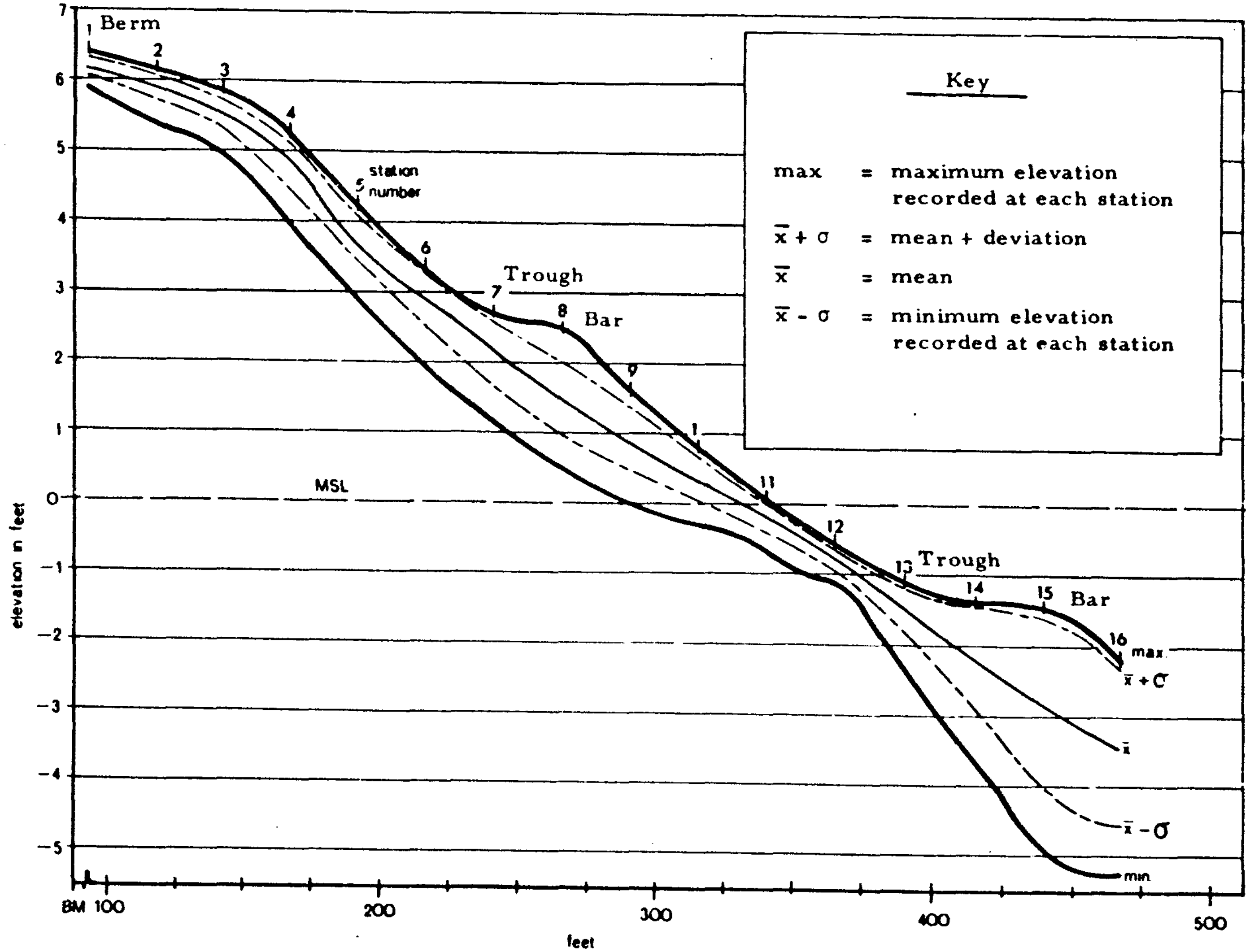



Fig. 44. SHORT-TERM, BETWEEN-TIDE VARIATIONS AT SITE 4, SUMMER PERIOD

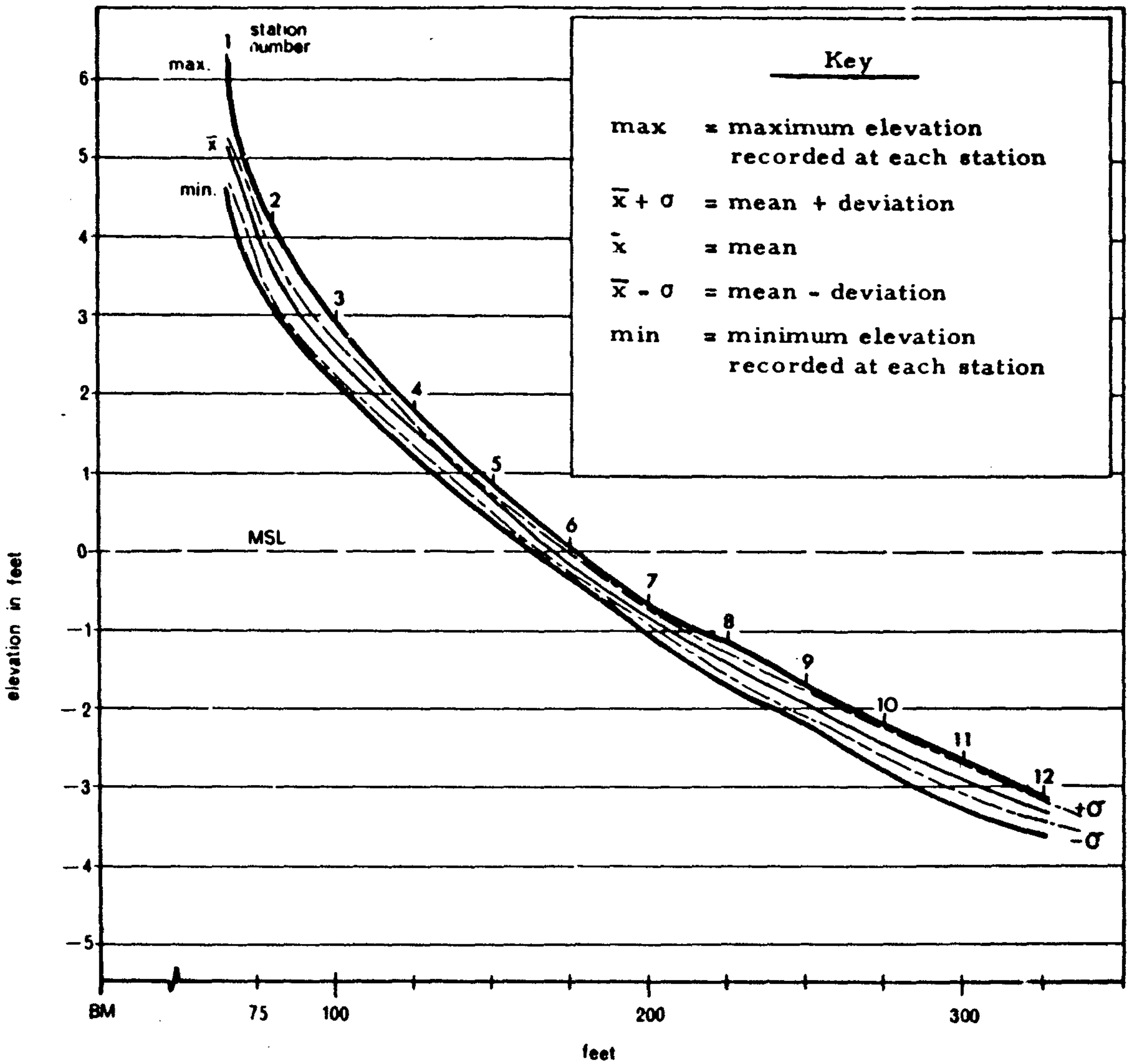



Fig. 45. SHORT-TERM, BETWEEN-TIDE VARIATIONS AT SITE 4, WINTER PERIOD

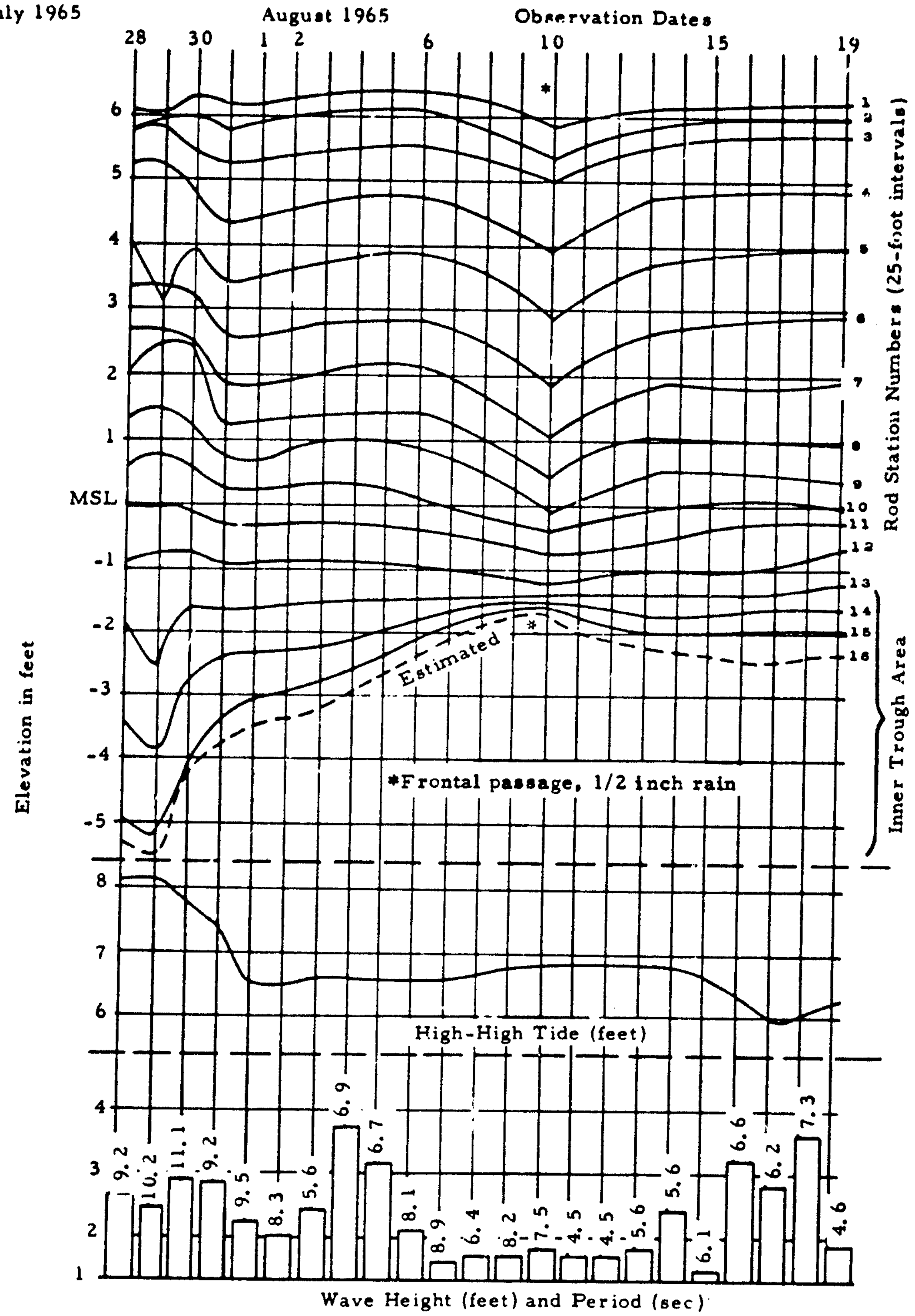



Fig. 46. SHORT INTENSIVE STUDY, SUMMER 1965

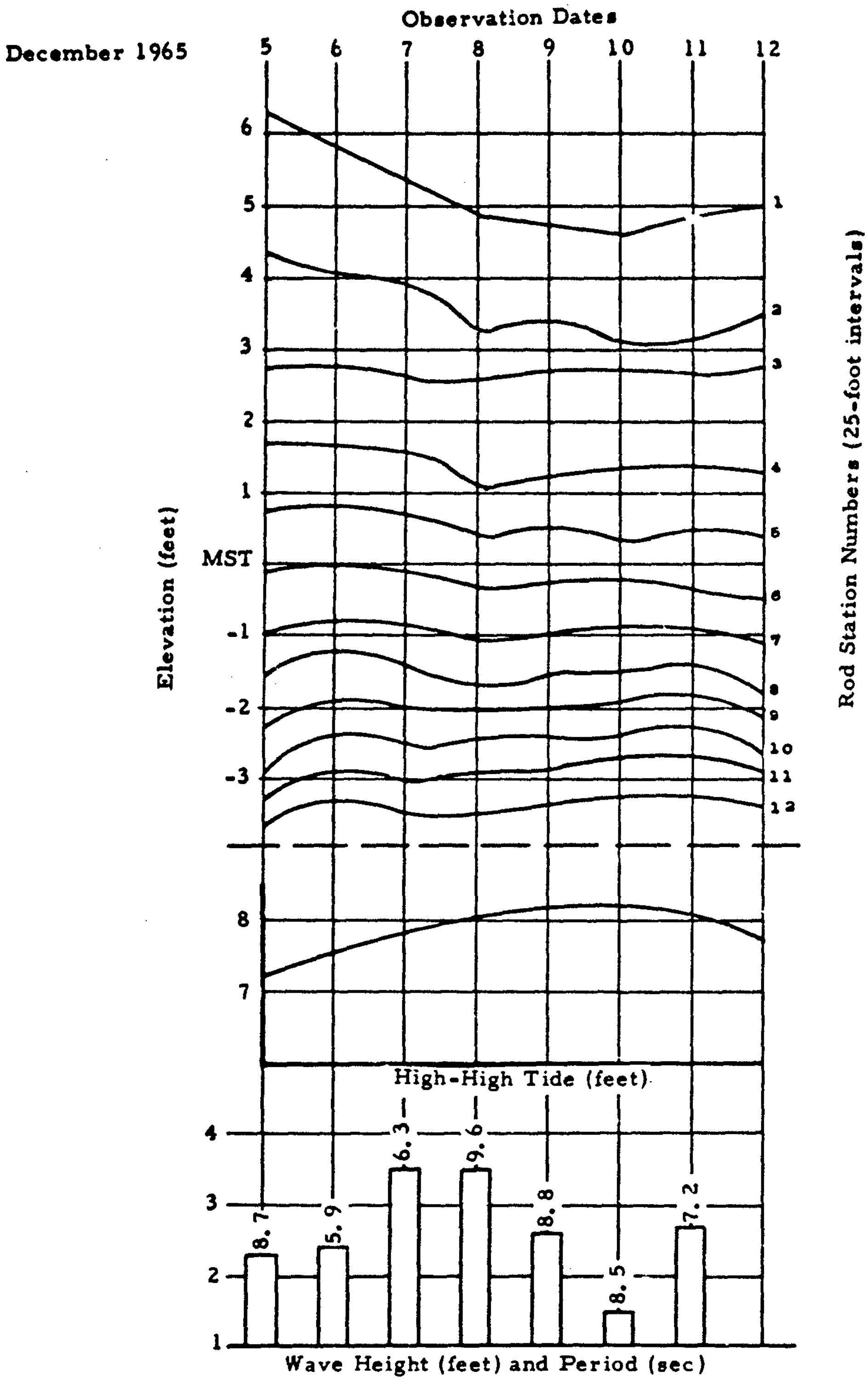



Fig. 47. SHORT INTENSIVE STUDY, WINTER 1965

Figure 48 illustrates the overall beach profile (line 4) at the approximate center of South Beach. Two different wave energy conditions were observed. Tide A (9 August 1965) and Tide B (11 August 1965). During Tide A, the wave energy was low; during Tide B, the energy was high. As shown graphically, sediment was deposited on the subaerial beach during Tide A but eroded during Tide B. The converse was happening over most of the submarine grid during these two tides.*

*As was stated in Paragraph VII of the Statement of Work, the project was to include examination of offshore conditions "within the scope of the project and capabilities of the personnel." Despite the limited results of the work, the experiment went relatively well. However, significant problems were encountered which may be of interest to other researchers who have not worked in the submarine zones of the beach save from the relatively dry confines of a pier. Therefore, although the problems and the solutions used do not add to the substance of this report, they are recapitulated in Appendix D.

Analysis of diffusion samples was inconclusive because the slides were contaminated as indicated by the control slides in each slide box.

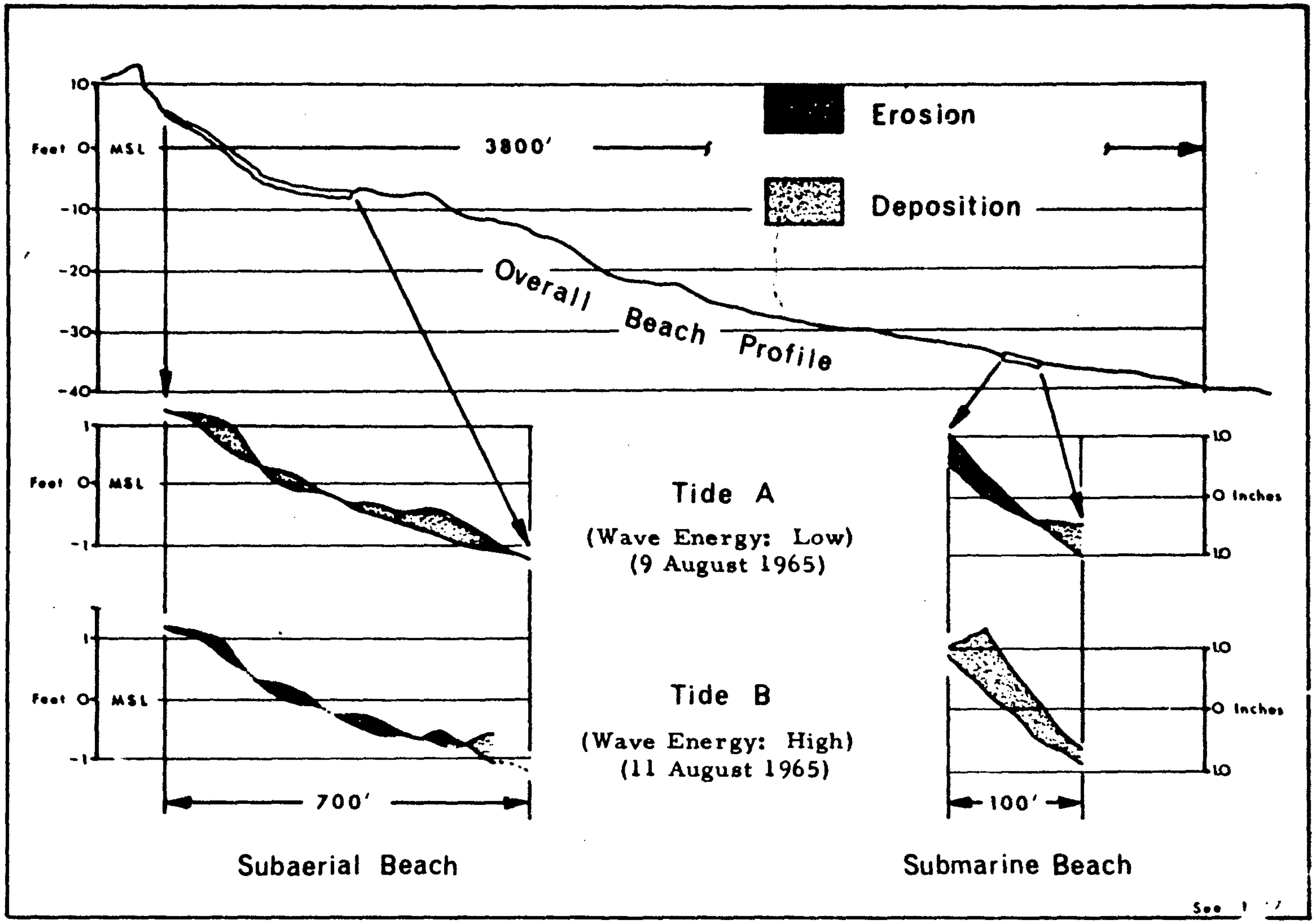



Fig. 48. SUMMARY OF OFFSHORE EXPERIMENT

## VI. SUMMARY AND RECOMMENDATIONS

Two principal conclusions have been reached through the study of South Beach. The conclusions are:

> First, that the coastal landforms and the processes observed on the beach are primarily controlled by the geomorphology of the Smith River Plain, and
>
> Second, that the beach does not exhibit the dynamics characteristic of most California beaches.

These conclusions are summarized in the following paragraphs together with several recommendations for future work.

### Controlling Influences of the Smith River Plain

Three factors of the geomorphology of the Smith River Plain are the main influences on the dynamics of South Beach. They are described in the following paragraphs.

#### Orientation

The principal factor is orientation. South Beach is protected by Point St. George and by the southwesterly trend of the coast range from sea or swell approaching from any but a south-southwest to west-southwest octant. In addition, the Point appears to block the normal coastal currents causing an eddy to exist during the summer season. As a result, the littoral currents along the beach have a northerly set in contrast to the southerly set of the deep water currents.

#### Tilting

Because of the uplift along Structural Trend III, the mouth of the Smith River, which is the principal source of sediments for the region, has been diverted to the north. Additionally, most of the sediments which do reach Point St. George are apparently lost to deep water as they pass the scarp associated with the Trend. Furthermore, it appears that the exposure of a wide platform along the Trend directly offshore from the beach dissipates a large amount of the wave energy approaching the beach from the southwest.

#### Sediment Sources

The sources for sediment on South Beach are limited to recent fluvial materials along its northwesterly half and fluvial materials from the

Pleistocene Battery Formation on the southeastern half. Erosion of sediment is principally from the latter source and only during periods of high-high tides or severe storm activity. Some sediments are also available from the Jurassic headlands to the south of the beach; coupled with the other elements of beach formation, this sediment is apparently sufficient to replenish the beach sand budget if sand is lost offshore, and to result in a state of relative equilibrium. The prevailing winds have little direct effect on the transportation of sediments to or along South Beach.

## Beach Dynamics

As noted above and described in Section V, South Beach, in contrast to the majority of California beaches, is not a dynamic beach. The characteristics of the beach and the relationships of the parameters affecting the beach are summarized in the following paragraphs.

### Characteristics of South Beach

During the eighteen months of the study, the beach showed a maximum of only six feet between seasonal profile and insignificant changes in the size and composition of the sediment matrix. As noted in the first conclusion, the causes of the apparent short- and long-term stability of the beach are principally connected to its relationship with the Smith River Plain. It is expected that additional studies of similarly exposed beaches will reflect similar characteristics.

### Relationship of Agents of Beach Formation

As stated previously, the most active agent of beach formation on South Beach was wave energy. Because the energy from waves propagated directly onto the beach without appreciable refraction from storms approaching the area along the southwestern storm track is dissipated by an offshore shelf, beach changes are not closely correlated with such storms. Furthermore, because the energy from waves generated by storms following the prevailing northwestern storm track is reduced by refraction around Point St. George, beach changes are not closely correlated to these storms. Hence the seasonal changes which do occur are related to the net increase in total wave energy, independent of direction, caused by the net increase in the number and intensity of storms generating waves which reach the study area. Within each season, summer and winter, the changes in elevation of the beach are related to tidal activity, e.g., the position of activity on the beach is directly related to the tide.

Neither currents nor precipitation were related to related to beach changes. Local winds may have had some local effects on the littoral currents, but it appears that current effects did not play a major role in beach formation. The role of precipitation in beach formation was obscured during the study of South Beach since for virtually the entire period of study the back beach, which might have responded to precipitation, was covered with driftwood.

## Recommendations for Future Studies

It is obvious that additional study will provide further valuable data on any region. However, for the purposes of possible follow-on to the present study or for similar studies, four recommendations are appropriate.

### Duration

As stated by Shepard (1963), "seasonal cycles are sometimes very erratic." Certainly a study based on eighteen months or two years of data is not of sufficient duration to determine possible erratic seasonal cycles. For basic purposes, however, it appears that a two-year program of observations is a minimum for an area in which climatic conditions are as variable as those along the Pacific Coast of the United States.

### Logistics

Directly related to duration is the problem of logistics. A permanent field station manned by at least one person whose sole responsibility is to make the beach observations is a definite requirement if an investigator is to obtain consistent and reliable periodic measurements.

### Wave Measurement

For any future investigations of this nature, at least one wave gauge should be installed in the study region. Despite the availability of suitable techniques for hindcasting waves, no such method can replace direct field measurements.

### Automatic Data Processing

Within the scope of the present project, it was impossible to undertake either comprehensive desk calculator or computer correlation of all of the dynamic processes influencing South Beach. Therefore, analysis was based on inspection of the data and graphic summaries which were sufficient to fulfill the project objectives. Further statistical analyses

of the data collected during the present study might provide additional information for analysis of the beach. For future studies of both limited and broad scope, it is recommended that all basic data, e g., sand measurements, wave observations or measurements, weather records, and other experimental measurements, be reduced to computer format to facilitate numerical analysis including frequency studies within a given parameter and correlation studies between parameters.

## BIBLIOGRAPHY


Back, William. 1957. Geology and Ground-Water Features of the Smith River Plain, Del Norte County, California. USGS Water-Supply Paper 1254.

Bascom, Willard. 1964. Waves and Beaches, the Dynamics of the Ocean Surface. Doubleday & Company, Inc., Garden City, New York.

Campbell, Ian. 1964. Geologic Map of California Weed Sheet. Division of Mines and Geology

Cherry, John. October 1965. Sand Movement Along a Portion of the Northern California Coast. Technical Memorandum No. 14, U.S. Army Coastal Engineering Research Center.

Dicken, Samuel. 1961. Some Recent Physical Changes of the Oregon Coast. Report on an investigation carried out under Contract Nonr-2771 (04), Project NR 388-062, between the University of Oregon and the Office of Naval Research, U.S. Department of the Navy.

Dolan, Robert and James McCloy. November 1964. Selected Bibliography on Beach Features and Related Nearshore Processes. Technical Report No. 23, Part A, Beach Process Studies. The first part of the 23rd in a series of reports obtained under Project No. Nonr 1575(03), Task Order No. NR 388 002 of the Geography Branch, Office of Naval Research.

Ingle, James C., Jr. 1962. Tracing Beach Sand Movement by Means of Fluorescent Dyed Sand. Shore and Beach, October 1962.

Ingle, James C., Jr. September 1966. The Movement of Beach Sand, An Analysis Using Fluorescent Grains. Abstract from Transactions of the American Geophysical Union, 47(3): 502-503.

Irwin, W. P. 1960. Geologic Reconnaissance of the Northern Coast Ranges and Klamath Mountains, California. California Division of Mines, Bulletin 179.

Johnson, James H. 1961. Sea Surface Temperature Monthly Average and Anomaly Charts Northeastern Pacific Ocean, 1947-1958. United States Fish and Wildlife Service Special Scientific Report, Fisheries No. 385.

Maxson, J. H. 1933. Economic Geology of Portions of Del Norte and Siskiyou Counties, Northwesternmost California. California Journal of Mines and Geology, 29(1 & 2): 123-160.

National Marine Consultants. December 1960. Wave Statistics for Seven Deep Water Stations Along the California Coast. Shore Protection Section (prepared for Department of the Army, U.S. Army Corps of Engineers)

Rantz, S.E. March 1965. Flood of December 1964 in Redwood Areas of North Coastal California. U.S. Department of the Interior Geological Survey, Water Resources Division.

Roberts, James A. 1964. The Reshaping of South Beach, Crescent City, California, After the Tsunami of 27-28 March 1964. Paper presented before the Beach Erosion Control Conference sponsored by the California State Department of Water Resources, Santa Monica, California, 2 December 1964.

Roberts, James A. and E. K. Kauper. October 1964. The Effects of Wind and Precipitation on the Modification of South Beach, Crescent City, California. Final Report, Contract DA-49-092-ARO-38, Atmospheric Research Group.

Roberts, James A. and Chen-Wu Chien. June 1965. The Effects of Bottom Topography on the Refraction of the Tsunami of 27-28 March 1964. The Crescent City Case, Proceedings of the Annual Meeting of the Marine Technology Society, Washington, D.C.

Roberts, James A. 1966. Utilization of SCUBA Techniques for Sediment Transport Studies. Paper presented before the Offshore Exploration Conference, Long Beach, California, 24 February 1966.

Saville, Thorndike, Jr. April 1966. Notes for Coastal Engineering. Lecture 8 in University of California Extension Series, Lectures on Ocean Engineering.

Shepard, Francis P. 1963. Submarine Geology. Harper and Row, New York (with chapters by D. L. Inman and E.D. Goldberg).

Snow, David T. August 1962. Beaches in Northwestern California. Institute of Engineering Research, Technical Report, Series 14, Issue 25, submitted under Contract DA-49-055-eng-8 with the Beach Erosion Board.

State of California Marine Research Committee. July 1963. California Cooperative Oceanic Fisheries Investigations, Atlas No. 1.

Taliaferro, N. L. 1942. Geologic History and Correlation of the Jurassic of Southewestern Oregon and California. Geol. Soc. America, Bulletin 53(1): 71-112.

Trask, Parker D., et al. January 1959. Mechanical Analyses of Beach Sands near San Francisco, California. Technical Report submitted under Contract DA-49-055-eng-8 with the Beach Erosion Board.

Trask, Parker D. and D. T. Snow. October 1961. Beaches Near San Francisco, California, 1957-1958. Technical Report submitted under Contract DA-49-055-eng-8 with the Beach Erosion Board

U.S. Army Coastal Engineering Research Center. 1966. Shore Protection Planning and Design. Technical Report No. 4.

U.S. Army Corps of Engineers. April 1959. Beaches Near San Francisco, California, 1956-1957, Technical Memorandum No. 110.

U.S. Army Corps of Engineers, Beach Erosion Board. October 1955. Sand Variation at Point Reyes Beach, California. Technical Memorandum No. 65.

U.S. Army Corps of Engineers, Beach Erosion Board. July 1956. Changes in Sand Level on the Beach and Shelf at La Jolla, California. Technical Memorandum No. 82.

U.S. Army Corps of Engineers, Beach Erosion Board. November 1956. Changes in Configuration of Point Reyes Beach, California, 1955-1956. Technical Memorandum No. 91.

U.S. Army Engineer District, San Francisco (CESF). June 1965. Cooperative Beach Erosion Study of the Coast of Northern California. Technical Report, Contract No. W-04-193-ENG 5196.

U.S. Army Engineer Division Laboratory, South Pacific. February 1966. Report of Soil Tests — Beach Sand Samples — Crescent City Beach Erosion Study.

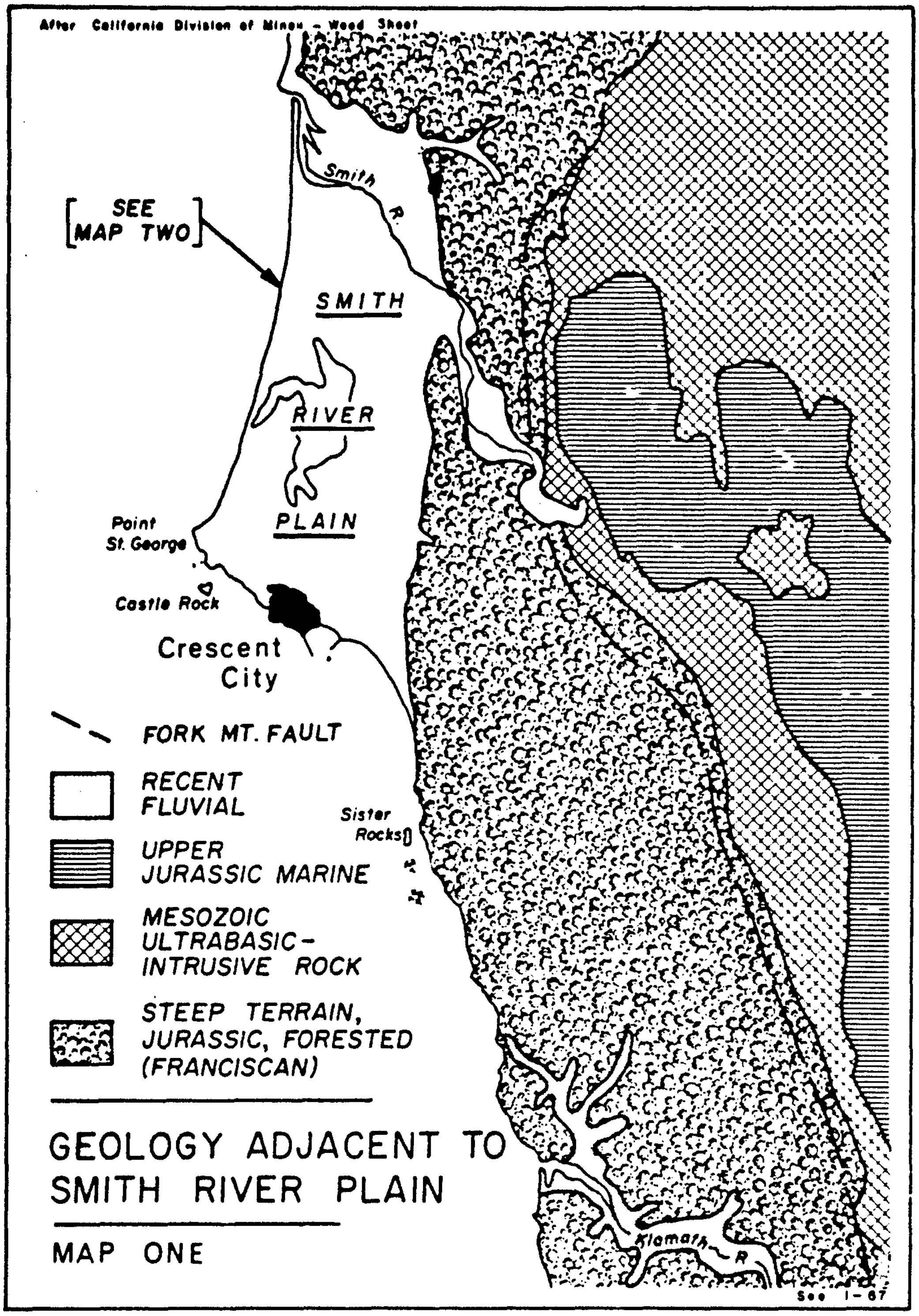
U.S. Navy, Chief of Naval Operations. July 1958. U.S. Navy Marine Climatic Atlas of the World, Volume II, North Pacific Ocean, NAVAER 50-1C-529.

Wiegel, Robert L. 1964. Oceanographical Engineering. Prentice-Hall, Inc., Englewood Cliffs, New Jersey

Wilson, J. Tuzo. October 1965. Transform Faults, Oceanic Ridges and Magnetic Anomalies Southwest of Vancouver Island. Science 150: 480-486, 22 October 1965.

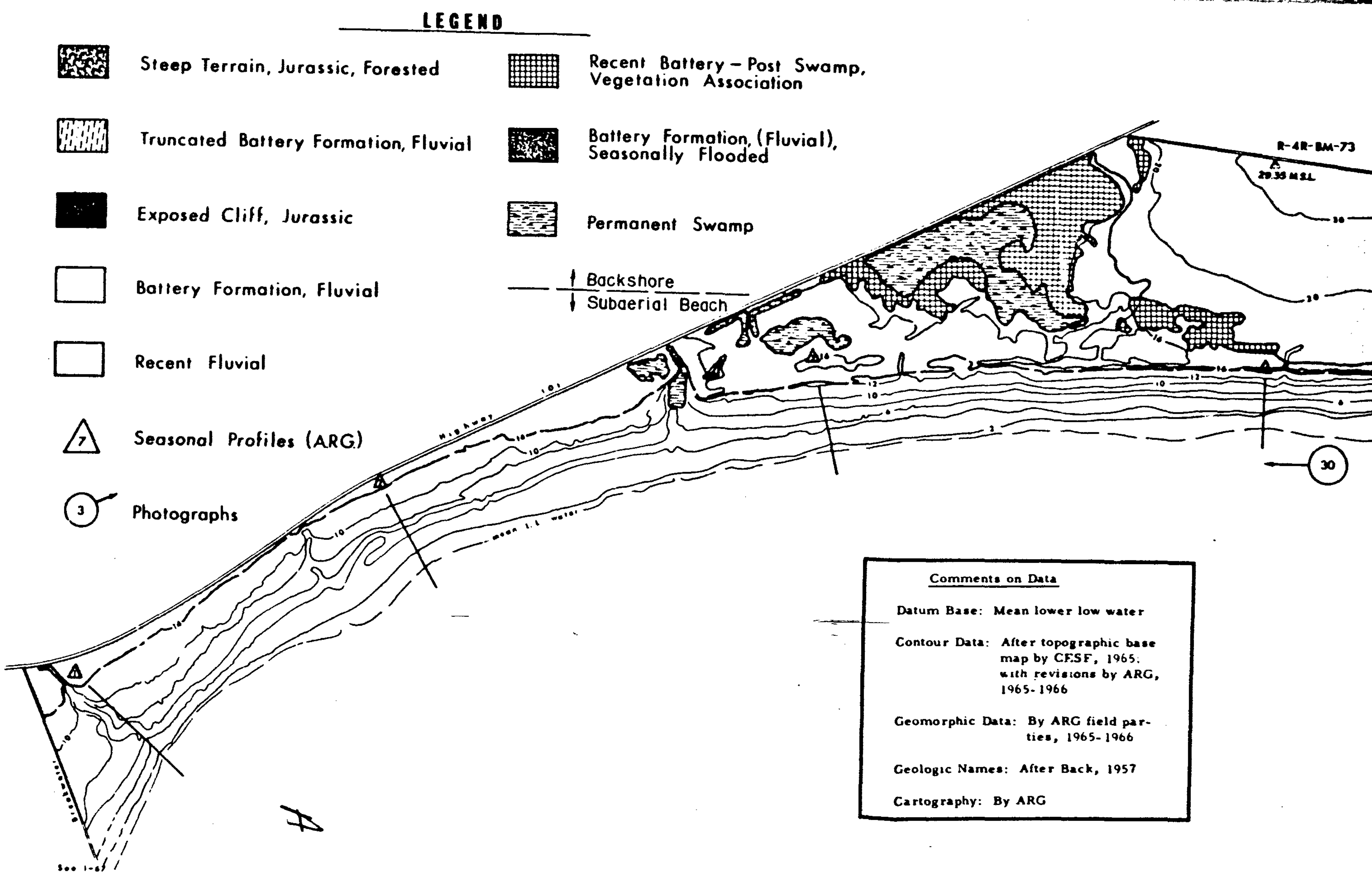
Wright, Frederick F. 1962. The Development and Application of a Fluorescent Marking Technique for Tracing Sand Movements on Beaches. Technical Report No. 2 of Project NR 388-057, Contract Nonr 266(68), AD 601219.

Zeller, R. P. August 1961. A General Reconnaissance of Coastal Dunes of California. Institute of Engineering Research, Technical Report Series 72, Issue 6 submitted under Contract DA-49-055-eng-17 with the Beach Erosion Board.

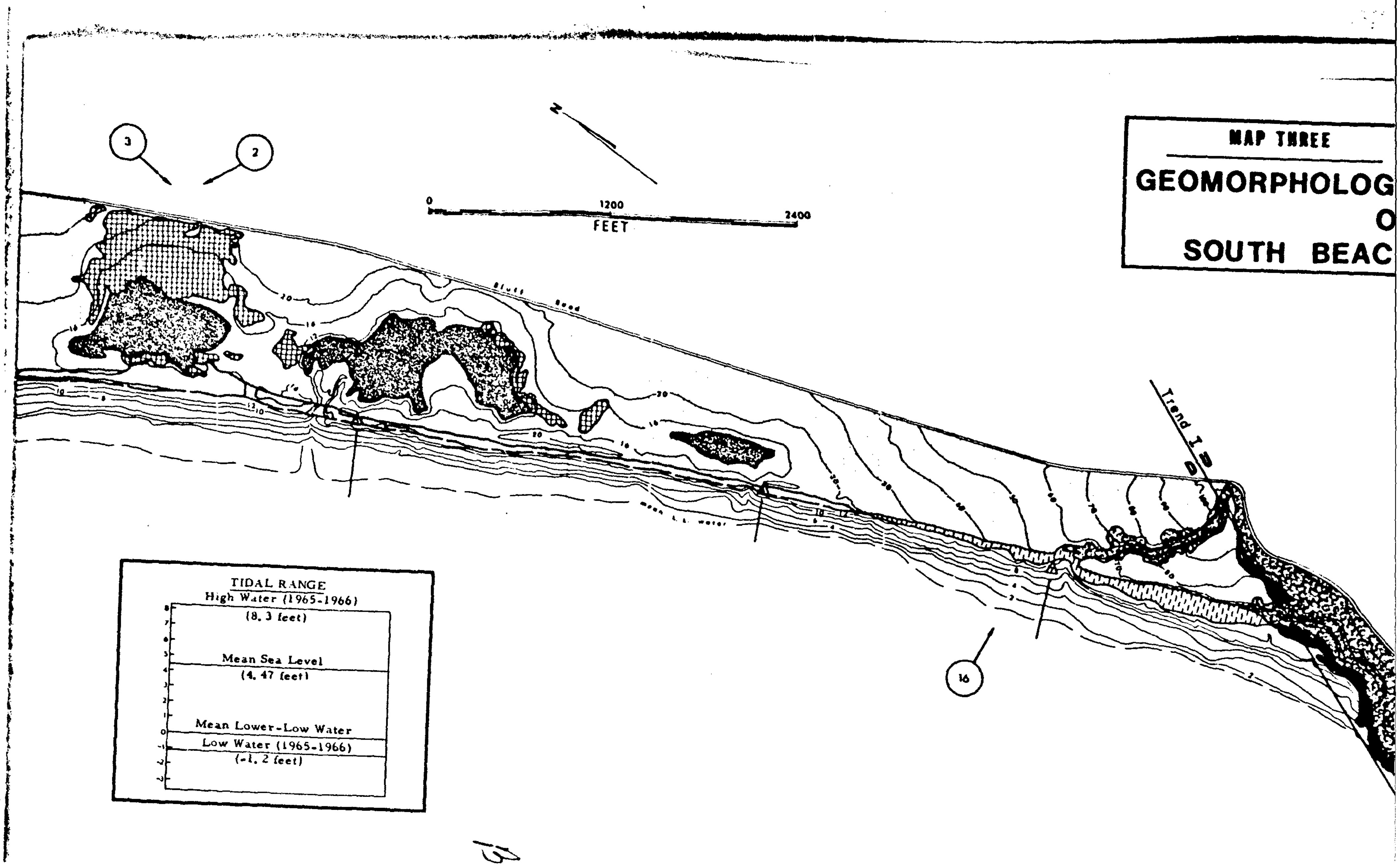



GEOLOGY ADJACENT TO SMITH RIVER PLAIN

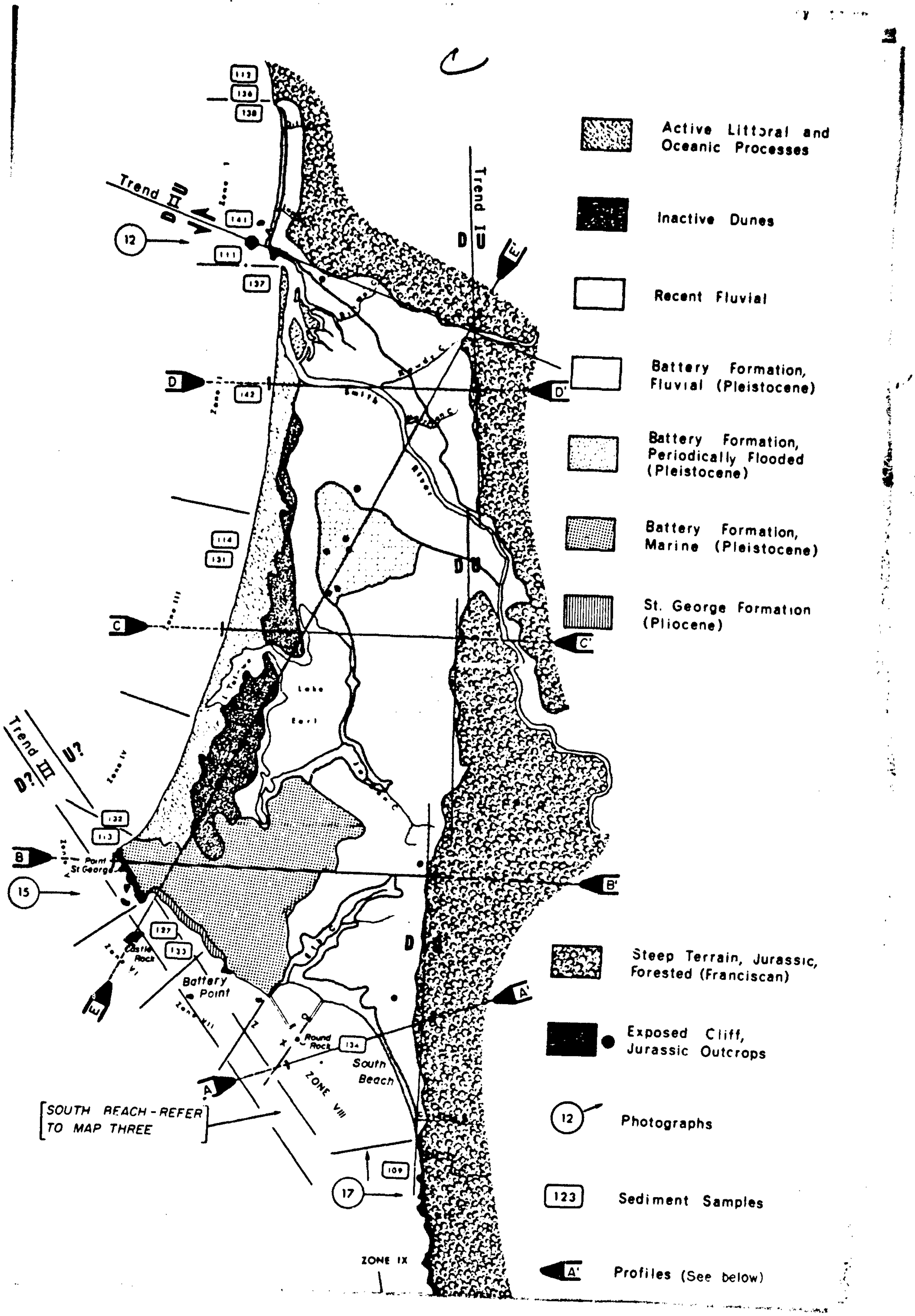
MAP ONE



LEGEND
Steep Terrain, Jurassic, Forested
Truncated Battery Formation, Fluvial
Exposed Cliff, Jurassic
Battery Formation, Fluvial
Recent Fluvial
Seasonal Profiles (ARG)
Photographs
Recent Battery – Post Swamp, Vegetation Association
Battery Formation, (Fluvial), Seasonally Flooded
Permanent Swamp
Backshore
Subaerial Beach
R-4R-BM-73
29.35 M.S.L.
Highway 101
30
A
Comments on Data
Datum Base: Mean lower low water
Contour Data: After topographic base map by CESF, 1965; with revisions by ARG, 1965-1966
Geomorphic Data: By ARG field parties, 1965-1966
Geologic Names: After Back, 1957
Cartography: By ARG

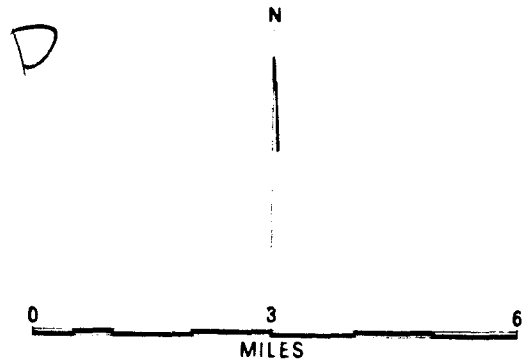


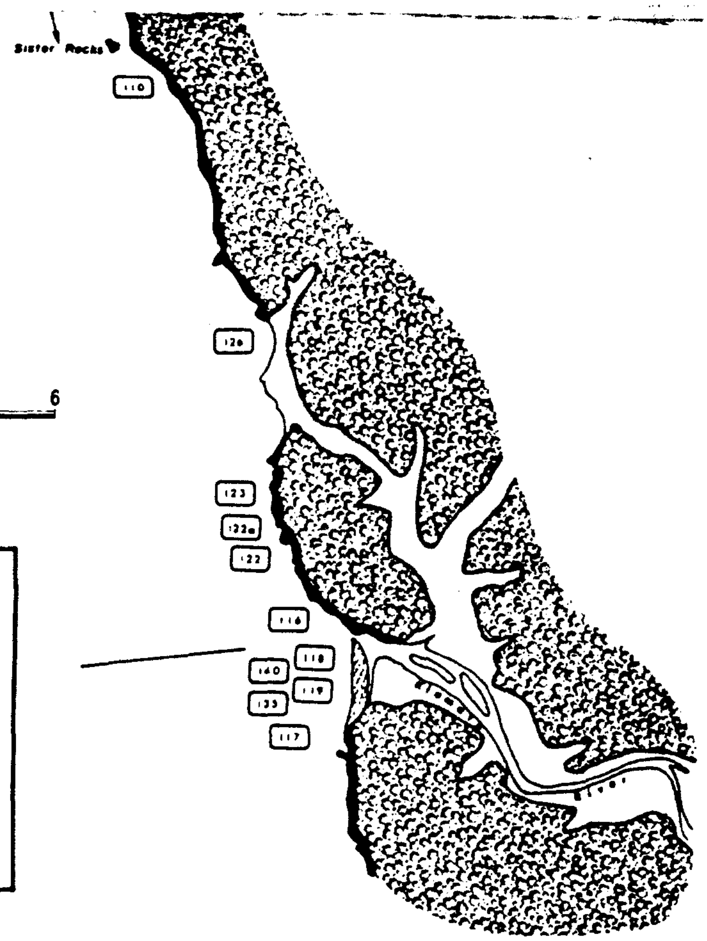
MAP THREE
GEOMORPHOLOG
O
SOUTH BEAC
N
0
1200
2400
FEET
3
2
16
Bluff Road
Trend I
D
Mean L.L. Water
TIDAL RANGE
High Water (1965-1966)
(8.3 feet)
Mean Sea Level
(4.47 feet)
Mean Lower-Low Water
Low Water (1965-1966)
(-1.2 feet)



Active Littoral and Oceanic Processes
Inactive Dunes
Recent Fluvial
Battery Formation, Fluvial (Pleistocene)
Battery Formation, Periodically Flooded (Pleistocene)
Battery Formation, Marine (Pleistocene)
St. George Formation (Pliocene)
Steep Terrain, Jurassic, Forested (Franciscan)
Exposed Cliff, Jurassic Outcrops
12
Photographs
123
Sediment Samples
A'
Profiles (See below)
Trend II
Trend I
Trend III
D U
D? U?
Smith River
Lake Earl
Point St George
Castle Rock
Battery Point
Round Rock
South Beach
ZONE VIII
ZONE IX
SOUTH BEACH - REFER TO MAP THREE
112
136
138
141
111
137
142
114
131
132
113
127
133
134
109
15
17

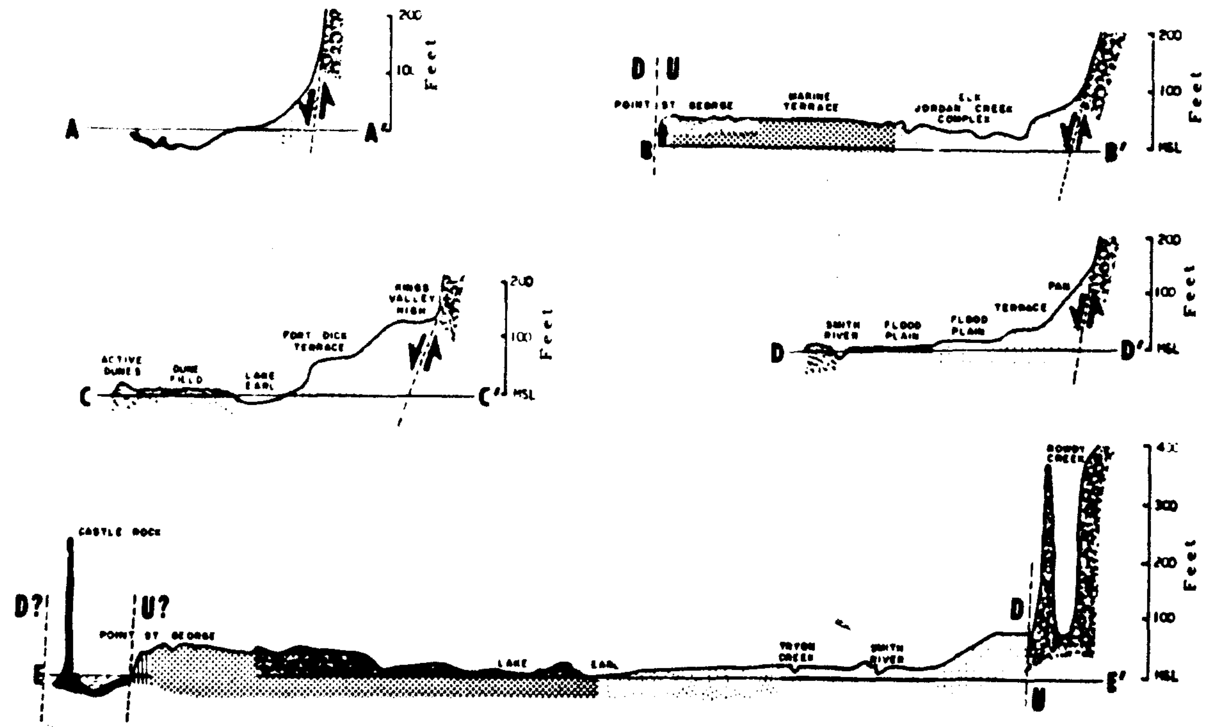
D




# GEOMORPHOLOGY OF THE SMITH RIVER PLAIN AND VICINITY

MAP TWO




Horizontal scale same as map scale

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13. ABSTRACT

Volume I of this report presents the results of a study of the dynamics of South Beach located adjacent to Crescent City, California, conducted under Contract No. DA 19-129-AMC-684(N) between Atmospheric Research Group and the U. S. Army Natick Laboratories. The objectives of the work were twofold: (1) to relate the beach dynamics to the overall morphology of the Smith River Plain, the region in which the beach is situated, and (2) to develop techniques to accomplish the study. The Smith River Plain is a lowland segment of the Klamath Mountains Province. The structure of the Plain is controlled by diastrophism. The general configuration of the Plain is controlled by location, orientation, and exposure of bedrock. To conduct the study within the scope of the project necessitated the selection of several key sites and the utilization of specialized sampling techniques for seasonal profiling and for short, intensive study. South Beach is an arcuate beach, about four miles in length, composed principally of medium to fine grained sands. The beach reflects only minor seasonal or tidal variability, and its configuration is controlled by its exposure to wave forces by local geomorphology.

Volume II presents a tabulation of the statistics collected during the study. They include: (1) summary of wind speed and wind direction data from an automatic Mechanical Weather Station located on South Beach, (2) measurements of beach dynamics on South Beach, (3) analysis of mineralogy of beach sediments, (4) explanation of the problems experienced with the underwater experiment, and (5) data from the offshore experiment. U

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